WEATHER

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WEATHER OF THE MONTH

JANUARY 1949

WEATHER

Vol. IV No. 1

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EDITORIAL

Meteorology is an international science ; the weather processes do not recognise frontiers created by man, nor do we pay import duties for rain arriving from another country. For many years weather data have been exchanged between countries, those for synoptic work being sent in an international code. A new set of codes (described in our last issue), was introduced on January 1 this year, which should result in an increase in the detail of the information available to the forecaster. On the face of it, some of the new codes appear to be unnecessarily refined ; how for example is an observer expected to distinguish between cloud heights of 7,900 and 8,000 ft. (codes 79 and 80) or between visibilities of 15,800 and 16,000 metres (codes 79 and 80) ? One reason for this feature of the new codes is to make the conversion easy, so that having agreed upon 200 metres as the fundamental interval for visibility (it is essential to be able to distinguish between 800 and 1,000 metres), this interval has been retained throughout most of the range. It is hoped that the introduction of photoelectric-visibility meters, pulsed light cloud searchlights (which use radar techniques rather than base line techniques for measuring distance) and other new instruments will eventually lead to a greater accuracy of observation so that full advantage can be taken of the new codes.

Other international features of meteorology are illustrated in this issue. We are glad to publish articles from America, Australia and Holland, dealing with subjects of interest to meteorologists throughout the world. On the personal side, the two articles on the work of Dr. L. F. Richardson show him to be a great internationalist as well as a meteorologist. In wishing our readers a very happy New Year, we express the hope that 1949 will be a year in which politicians and economists will introduce new codes of understanding between the nations—they could learn about more things than the weather from meteorologists.

THE WEATHER OF 1948 IN GREAT BRITAIN

(Information supplied by the Meteorological Office, London)

A WARM, SUNNY SPRING BUT A POOR SUMMER

The year was characterized by an exceptionally sunny and warm spring but a poor summer, culminating in the phenomenal rainfalls of the first half of August. In the later months of the year there were few outstanding features, the most notable event being the fog of late November.

January was wet and stormy. Over England and Wales as a whole it was the wettest January on record, the excess being greatest in the West and North. It was on the whole a mild month in the South, but in Scotland it was colder than the average and there was much snow lying in some inland areas.

The first half of February was mild and unsettled, but there was a cold spell of about ten days in the second half, which was notably severe in the South for three days between 20th and 22nd. East Malling (Kent), had a minimum of 5°F. on 22nd, and there was deep snow all over the southeastern area, with heavy drifting at exposed places. Biggin Hill had 14 inches of level snow, Croydon 10 inches, Guernsey 6 inches and Scilly 2 inches.

From the beginning of March till May 22 fine warm weather predominated. All three months had an excess of sunshine in most areas and the aggregates for the three months were quite outstanding. The April total was specially good in the Southeast, where Hampstead had the best record since 1914, and the May totals were exceptionally good in the West and North. At many places in the West it was the sunniest May on record. Both the Easter and Whitsun holidays were favoured with sunny weather.

On May 23 there was a complete change to cool unsettled weather, and these conditions continued till about July 18 with only short breaks. There was an exceptionally dull, cool period in the East and Midlands between July 9 and 17, though rainfall was not large.

In the last week of July there was a spell of exceptional heat over the whole country, with temperatures over 90°F. extending even to some western coastal areas as far north as Southwest Scotland. At Kew the maximum of 93°F. on 28th, and the minimum of 70°F. on the following night, were the highest on record for July in the 78 years of observations at that station; August 9, 1911, was the only hotter day on record there. There were some severe local thunderstorms, especially in western districts.

The fine spell broke up with widespread heavy rain and thunderstorms on Bank Holiday, August 2, and the next ten days were exceptionally rainy over nearly the whole country. The wet spell culminated in the Tweed Floods of August 12, when over 6 inches of rain fell in 24 hours in the Kelso area, and over 4 inches fell over an area of 800 square miles. It was much the heaviest rainstorm ever recorded in that area, and enormous damage was done by floods.

The autumn was on the whole a dry one over most of the country, though September was wet in the Northwest. November was mild for the fourth successive year. At the end of the month there was a period of four to five days of continuous fog, often dense, over a large area in the eastern and central districts of England.

The first half of December was abnormally mild but the second half was mainly cold, notably on the 26th and 27th. Widespread snow fell in the Midlands and North Wales on 30th.

INTERESTING AND NOTEWORTHY FEATURES MONTH BY MONTH

JANUARY STORMY AND VERY WET

Cold in the North, with night minimum temperature 4°F. at Logie Coldstone (Aberdeen) on 24th. Very mild at times in the South. Mildest day 60°F. at Cannington (Somerset) on 3rd.

Frequent snow in the North. Drifts 5 to 6 feet in depth blocked main roads in Central Scotland. Rainfall 4½ times the average in Durham and double the average over England and Wales generally.

Gales on 15 days in South Wales and on 13 days at the Scillies. Wind gust 81 m.p.h. at Bell Rock Lighthouse.

FEBRUARY HEAVY SNOWFALLS

Large temperature extremes. Coldest night 5°F. at East Malling (Kent) on 22nd. Mildest day 64°F. at Milford (Surrey) on 29th.

Much snow 20th-22nd, especially in Southeast England. Level snow 14 inches deep in Kent on 22nd and 6 inches even in the Channel Islands.

MARCH RECORD HIGH TEMPERATURES

Cold first few days then consistently warm. Temperature 71°F. at Kew Observatory on 9th, was the warmest March day there in records going back to 1870. Wealdstone (Middlesex) reached 75°F Temperature rose to 71°F. in Scotland on 26th.

Rainfall about half the average over England and Wales

Sunshine much above average.

APRIL WARM AND SUNNY

Mean temperature over England and Wales above average for the 13th successive month, though rather cold at beginning and end of month with some snow in the North. Snow 3 inches deep at Bellingham (Northumberland) on 30th.

Sunniest April since 1914 in London and excess of sunshine almost everywhere.

MAY SUNNY. HOT SPELL MID-MONTH. LATE FROSTS

Cold at beginning and end of month with an intervening hot spell. Temperature 82°F. at Bournemouth and Southampton on 17th. Night minimum 21°F. at Glenlivet (Banff) on 3rd.

Frequent thunderstorms. Hail 6 inches deep at White Waltham (Berkshire) on 1st.

Sunniest May on record at many places. Sunshine averaged more than 10 hours per day in Southwest England.

JUNE DULL, WET AND RATHER COOL

A few warm days but temperature mainly below average. Warmest day 83°F. at Earls Colne (Essex) on 13th. Local air frost in Scotland on 18th.

Rain on 25 days in Wales. Thunderstorms on 9 days in Suffolk. Rainfall totals three times the average in some parts, but less in areas which escaped the thunderstorms.

Dullest June on record at Newquay (Cornwall).

JULY HOT AND SUNNY WEEK AFTER LONG COOL SPELL

Cool on the whole until 25th, then extremely hot, culminating with a temperature of 95°F. at Milford (Surrey) on 28th. 90°F. in South Scotland for the first time in July since 1911.

Rain frequent but amounts not generally large.

Dull most of month. Unusually sunny last 6 or 7 days.

AUGUST COOL AND WET. GALES IN THE SOUTH

Consistently cool from 3rd onwards.

Heavy thunderstorms on Bank Holiday. Heavy rain during the gale of 7th. Local flooding in Essex.

Sunshine much below normal.

SEPTEMBER MAINLY DRY AFTER FIRST FORTNIGHT

No outstanding warm spell. Warmest day in some parts occurred during the last week.

Wet in the Northwest but little rain elsewhere after first fortnight.

Large sunshine deficiency in the West.

OCTOBER MAINLY DRY. SNOW IN SCOTLAND AND WALES

Fairly consistently mild until 24th then much colder. Generally keen air frost on 27th. Night minimum temperature 11°F. at Dalwhinnie on 28th.

Snow in North and Northwest Scotland on 25th and 26th and in parts of Wales on 28th.

NOVEMBER LONG FOGGY SPELL

Mild on the whole but some sharp night frosts.

Rainfall well below average especially in the West and North.

Fog intermittent in England from 22nd onwards and continuous fog in Central London for 114 hours, but sunny in Southwest England and along the South Coast for much of the foggy period.

DECEMBER ABNORMALLY MILD, THEN COLD

Consistently mild until mid-month. Temperature reading of 62°F. at Llandudno on 2nd equalled the December record at Greenwich in 1848. Some hard frosts on 26th and 27th. Night minimum 15°F. at Bristol on 26th.

Frequent gales and heavy rain in the West, especially during the first fortnight. Wind reached 93 m.p.h. in gusts at Pembroke on 7th. Widespread snow in the Midlands and North Wales on 30th.

THE YEAR IN LONDON

SUNNY SPRING. DULL SUMMER

Cold snap late February and cool summer offset by warm spring and mild autumn. Mean temperature above average.

Rainfall deficit of 2½ inches at Kew Observatory over the year.

Sunniest spring since that of 1909 but deficit of 100 hours sunshine from June to August. Year's sunshine total at Kew above average for the first time since 1940.

PUBLIC HOLIDAYS

Easter (March 26-29)—Sunny and very mild Good Friday to Easter Sunday. Cloudy with some slight rain on Easter Monday.

Whitsun (May 15-17)—Sunniest Whitsun weekend of the present century at Kew. More than 14 hours sunshine each day from Saturday to Monday.

August Weekend (July 31 to Aug. 2)—Fairly warm and sunny Saturday and Sunday. General rain began Monday afternoon.

Christmas—Cold and dry. Some hard night frosts. Fog and frost all day on 26th.

METEOROLOGICAL PUBLICATIONS BY L. F. RICHARDSON AS THEY APPEAR TO HIM IN OCTOBER 1948

These researches were nourished by several organizations. Without the Meteorological Office I should never have begun. Without it, together with the Royal Society, the Royal Meteorological Society, and the two international organizations, I might not have continued. The persons who took part were so numerous that their names must be sought in the original print; but I remember with especial gratitude the direction, pay, and encouragement from Sir Napier Shaw, the meteorological wisdom of Mr. W. H. Dines, and the inspiration from the writings of Prof. Vilhelm Bjerknes and of G. I. (now Sir Geoffrey) Taylor.

1. 1919.—*Measurement of water in clouds.* Proc. Roy. Soc. A, Vol. 96, pp. 19–31. Photometric measurements by three instruments: (*a*) for clouds through which the sun's disk appears sharp-edged, (*b*) for uniform stratus, (*c*) for the reflectivity of the ground. Continued in Nos. 16, 17, 23, 25. Errata: $\sqrt{2}$ is misplaced in equations (21), (23), (34).

2. 1919.—*Atmospheric stirring measured by precipitation.* Proc. Roy. Soc. A, Vol. 96, pp. 9–18. The averages are taken over horizontal surfaces enclosing the globe. See No. 26. Erratum: p. 12, after equation (17), for "If ξ" read "If ξ/ρ".

3. 1920.—*Some measurements of atmospheric turbulence.* Philos. Trans. A, Vol. 221, pp. 1–28. Many observations in diverse circumstances. Errata: in heading of table II, for $\sec^{-1} 10^3$ read $\sec^{-1} 10^{-3}$; delete page 9; insert minus in equation (32).

4. 1920.—*The supply of energy from and to atmospheric eddies.* Proc. Roy. Soc. A, Vol. 97, pp. 354–373. A criterion of just-no-turbulence is deduced from thermodynamics. The argument avoids the concept of mixing-length. Simplification and confirmation followed in No. 15. The number which others have since called "Richardson's number" is defined by equation (6.6). The effect of expansion on eddying energy is also deduced. Errata: a minus should be inserted in equations (3.4), (3.5) and in the italicized summary on page 362; in the second member of (6.4), $\partial\acute{\sigma}/\partial p$ should be squared.

5. 1921.—*Lizard balloons for signalling the ratio of pressure to temperature.* Prof. Notes Met. Off., No. 18. The balloon signalled by dropping its tail.

6. 1921.—*Cracker balloons for signalling temperature.* Prof. Notes Met. Off., No. 19. A thermometer fired an explosive.

7. 1922.—*Weather prediction by numerical Process.* Cambridge University Press. This research was begun in 1913 as an exercise on finite differences suggested by Philos. Trans. A., Vol. 210, pp. 307–357; but it became the unifying idea to which all my other meteorological work was attached. The book shows how all the then known atmospherical processes can be fitted together into a lattice-reproducing numerical system. In 1922 numerical

prediction appeared to be impossible for four reasons: (i) The slowness of arithmetic. Modern electronic machines have provided the requisite speed. (ii) Winds above clouds were unexplored. They are now regularly observed by radio-sondes and could be by spheres shot upwards. (iii) Inadequate statistical information about eddies, about reflectivity, about water in clouds, and about ozone. Much more is now known about each of these. (iv) The random location of observatories. They are still not arranged in the appropriate pattern, which is like a chessboard, where pressure should be observed above the centre of each black chequer, and wind above the centre of each white chequer. Errata: see printed slip headed " additional errata ".

8 1922.—*Computing forms* for No. 7, published separately. Cambridge University Press.

9. 1922.—(With Dr. A. Wagner and Dr. R. Dietzius.) *An observational test of the geostrophic approximation in the stratosphere.* Quart. J.R. Met. Soc., Vol. 48, pp. 328–341. Shows that the geostrophic wind is an inadequate conception even where friction is negligible.

10. 1923.—*Wind above the night-calm at Benson at 7 a.m.* Quart. J.R. Met. Soc., Vol. 49, p. 34. Strong winds, beginning at about 150 metres above ground, were observed by spheres shot upwards.

11. 1923.—*Theory of the measurement of wind by shooting spheres upward.* Philos. Trans. A, Vol. 223, pp. 345–382. An integral-equation is approximated by layers of wind.

12. 1924.—*How to observe the wind by shooting spheres upward.* Prof. Notes Met. Off., No. 34.

13. 1924.—*Attempts to measure air-temperature by shooting spheres upward.* Quart. J.R. Met. Soc., Vol. 50, pp. 19–22.

14. 1924.—*The aerodynamic resistance of spheres shot upward to measure the wind.* Proc. Phys. Soc., Vol. 36, pp. 67–80.

The purpose of researches 10, 11, 12, 14 was to make rapid measurements of wind above fog or low cloud. That is now done by radio-sondes to far greater heights. Yet the projectiles have two advantages, namely cheapness and verticality: (i) A cheapness which permits frequent observations; for the lost balls cost far less than the lost radio-sonde. A gun of merely 0·8 cm. bore can reach the height of the Eiffel Tower, and so get above many fogs. (ii) The projectiles give the wind almost vertically above the gun, and thus would extend, to the upper air, the regular pattern of ground-stations recommended in No. 7.

15. 1925.—*Turbulence and vertical temperature difference near trees.* Phil. Mag., Vol. 49, pp. 81–90. Simplifies the theory of No. 4 and compares it with observation.

16. 1925.—*The brown corona and the diameters of particles.* Quart. J.R. Met. Soc., Vol. 51, pp. 1–6. Laboratory measurements, intended for application to clouds, were made on solid spheres.

17. 1925.—*Photometric observations on clouds and clear skies.* Quart. J.R. Met. Soc., Vol. 51, pp. 7–23. A continuation of No. 1 with a much improved

instrument. Measurements of the "equivalent rainfall". Strange property of clear sky at sunset.

18. 1926.—*Atmospheric diffusion shown on a distance-neighbour graph.* Proc. Roy. Soc. A, Vol. 110, pp. 709–737. Introduces the concept of "diffusivity for neighbours" $F(l)$ as a function of their separation, l, and shows from observations that $F(l)=0{\cdot}4\ l^{4/3}$ in centimetre-second units. Leads to Nos. 24, 26, 27.

19. 1926.—(With Denis Proctor.) *Diffusion over distances ranging from 3 km. to 86 km.* Memoirs of the R. Met. Soc., No. 1. The records of volcanic ash and of toy-balloon races were reduced to diffusivities. Erratum: p. 7, line 4, for $\sigma=86$ read $\sigma=43$.

20. 1926.—(With Russell E. Munday.) *The single-layer problem in the atmosphere and the height-integral of pressure.* Memoirs of the R. Met. Soc. No. 2. The dynamical height of the atmosphere, as defined in tidal theory, is computed from the records of sounding balloons and found to be extremely variable. This explains why Laplace's dynamical equations, for an ocean of constant depth, will not serve for weather prediction. Erratum: in § 4, equation (2), for P' read $2P'$.

21. 1926.—(With Denis Proctor and Robert C. Smith.) *The variance of upper wind and the accumulation of mass.* Memoirs of the R. Met. Soc., No. 4. In the chessboard-pattern of No. 7, four wind-stations are supposed to surround each pressure station. The structure of the wind as observed by balloons is found to be such that a pattern of large squares would give more accurate time-rates of pressure than would a pattern of small squares. This characteristic of the wind is opposite to that of the functions discussed in books on interpolation. This may perhaps be the crucial difficulty of the proposal for forecasting in No. 7.

22. 1927.—(As secretary to a committee.) *Meteorological studies in connection with the Toronto meeting of the British Association.* Quart. J.R. Met. Soc., Vol. 53, pp. 295–300. Observations of vertical temperature gradients in the first 44 metres above the North Atlantic.

23. 1928.—*Report on photometers for a survey of the reflectivity of the earth's surface.* Union Géodésique et Géophysique Internationale, Section de Météorologie, Prague, 1927. The white wedge photometer of No. 1 was improved and the observations with it were collected. Erratum: on p. 7, in the formula for dL delete 2 before cos $2d$.

24. 1929.—*A search for the law of atmospheric diffusion.* Beitrag zur Physike der Freien Atmosphäre, Hergesell Festschrift. Contains the first observations on the diffusivity-for-neighbours made by observing pairs of particles as recommended in No. 18. The observations cannot be reconciled with Fick's law of diffusion. Attempts to improve that law, by adding higher derivatives with constant coefficients, are of no avail. Misprint: in equation (10) the lower termini should be 0, not ∞. Mistake: it is asserted in (7) that the equation for diffusion must be linear in the concentration and its derivatives. J. A. Gaunt pointed out that it need only be homogeneous. This opens wider possibilities.

25. 1930.—*Reflectivity of woodland, fields and suburbs between London and St. Albans.* Quart. J.R. Met. Soc., Vol. 61, pp. 31–38. Further observations with the white wedge photometer of No. 23 from an aeroplane.

26. 1930.—(With J. Arthur Gaunt, M.A.) *Diffusion regarded as a compensation for smoothing,* Memoirs of the R. Met. Soc., No. 30. Not merely the diffusivity, but the form of the law in which any such constant appears, may depend on what detail is averaged out. The laws appropriate to different types of average are specified.

27. 1948.—(With Henry Stommel.) *Note on eddy-diffusion in the sea.* Journal of Meteorology, Vol. 5, pp. 238-240. A measurement of the diffusivity for neighbours, as defined in No. 18, gave $F(l)=0{\cdot}07\ l^{1{\cdot}4}$ in the sea. This power of l agrees, within the random uncertainty, with $l^{4/3}$ previously observed in the atmosphere (Nos. 18 and 24). Some such power of l is probably therefore a general characteristic of fluids which occupy large spaces. C. F. von Weizäcker has deduced something closely similar from abstract principles.

L. F. Richardson

LEWIS F. RICHARDSON, D.Sc., F.R.S.

L. F. Richardson must surely be one of the most original thinkers that has ever been attracted to the science of meteorology. The article on page 6 dealing with his most important meteorological publications illustrates the diversity of his contributions to the subject, and shows how his work is a rare combination of theoretical and experimental ability. The object of this note is to give readers a picture of the man behind the name.

Dr. Richardson, who is a member of the well-known Quaker family, was born at Newcastle-on-Tyne in 1881. He finished his schooling at Bootham School, York, which is famous for its encouragement of leisure-hour pursuits; all prizes are awarded for work done outside the classroom, and it claims to have the oldest school Natural History Club in the world. From there he passed on to Durham College of Science and then to King's College, Cambridge, where he took his B.A. Natural Science Tripos, 1st Class, Part I, in 1903. Before joining the Meteorological Office, L. F. Richardson worked for three years at the National Physical Laboratory, and also spent some years at a tungsten lamp factory.

In 1913 he was appointed Superintendent of Eskdalemuir Geophysical Observatory, where he started work on the most absorbing problem of forecasting the weather by rigid calculation. He remained there until joining the Friends' Ambulance Unit, along with many other Quakers and pacifists, in 1916. During his two and a half years' service in France his thoughts frequently returned to his researches, and he revised the first draft of his book on weather forecasting. On returning to civil life, Dr. Richardson was posted to Benson Observatory, then at the height of its fame under W. H. Dines, where he was able to carry on with his researches. It must have been a blow to his colleagues

when he decided, for pacifist reasons, to resign from the Meteorological Office on its being taken over by the Air Ministry in 1920. From then until his retirement in 1940, he worked in the education world, first at Westminster Training College and latterly as Principal of Paisley Technical College. In spite of the onerous duties of his profession, he at first found time to pursue his meteorological investigations. His magnum opus, *Weather Prediction by Numerical Process*, was eventually published in 1922 and was followed by many other important papers.

As might be expected in a man of Quaker upbringing, Dr. Richardson often wondered how his abilities could best be used to serve mankind, and he gradually turned away from meteorology to pioneer a completely new subject, a mathematical and psychological analysis of the causes of war. How rare it must be for a scientist honoured with a D.Sc. and F.R.S. (in 1926) to start studying again and take a B.Sc. in psychology (in 1929) ! His new researches absorbed more and more of his time, and one of the main reasons for his early retirement was to enable him to devote all his energies to his task. From then on meteorology was regarded as a temptation to be resisted, so that his thoughts could be concentrated on his service to world peace. *Generalized Foreign Politics*, published in 1939, showed how this apparently abstruse mathematical work could produce results of great practical value, and it is greatly regretted that the revised and extended edition, *Arms and Insecurity*, is so far only available in microfilm.

Dr. Richardson has thus produced brilliantly original conceptions in two different fields, numerical methods of forecasting the weather and an analysis of the causes of war. Meteorologists may wonder with regret what further advances would have been made if he had continued with his meteorological investigations. The development of electronic calculating machines has led to a wide appreciation of the practical possibilities of his weather forecasting technique. On the other hand, posterity may well decide that his war analysis is of even greater importance, and we hope that politicians will realize its practical significance before it is too late to reverse the present trend towards a third world war.

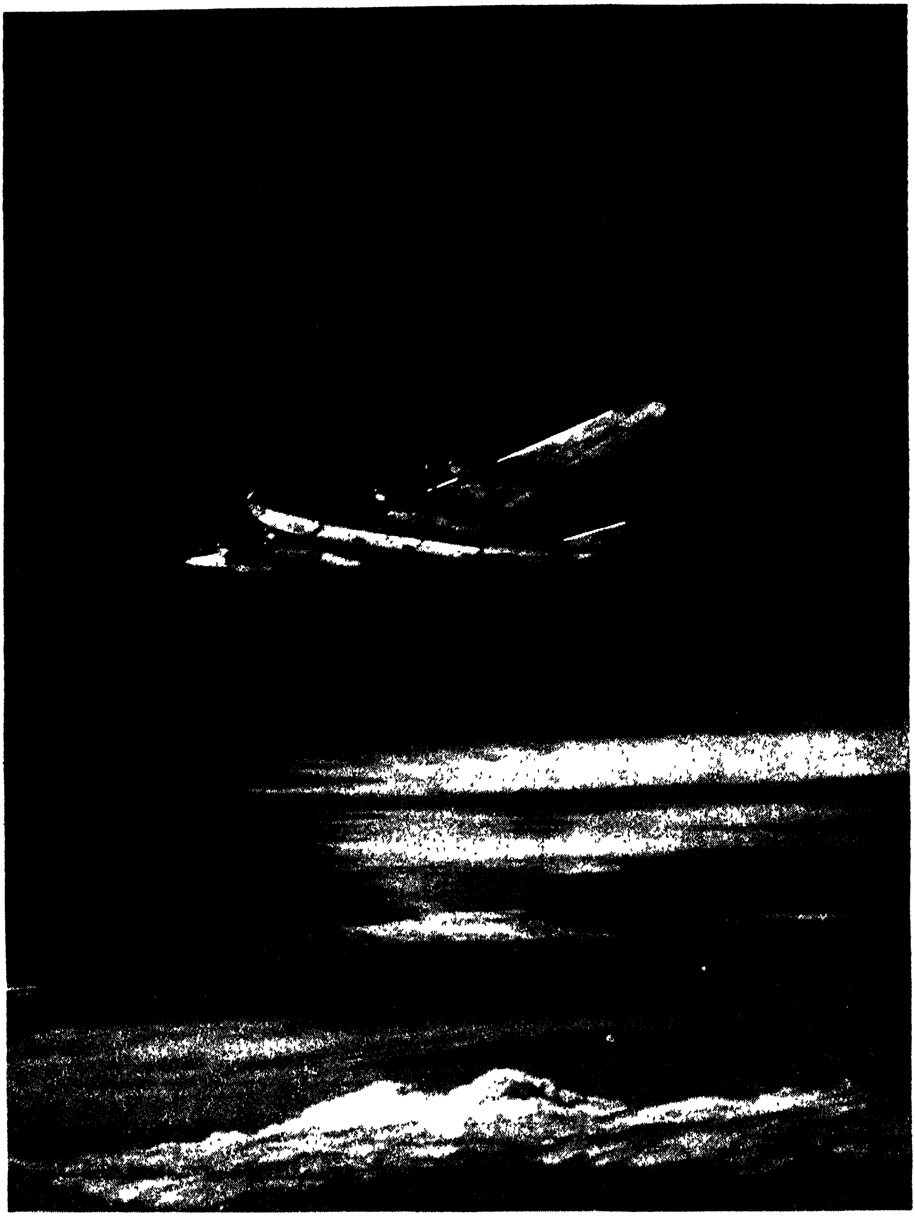
In spite of his own brilliance, Dr. Richardson is a most patient teacher, and no student who ever had the privilege of attending his physics classes will forget the kindly interest he always took in his pupils. By nature of a quiet disposition, he could still give a word of warning when the occasion demanded it, and woe betide the innocent assistant who entered the Superintendent's Office at Eskdalemuir when the presence of a hat on the door handle indicated that Dr. Richardson was at work and not to be disturbed ! His fine sense of humour is not often displayed, but those who doubt its existence should read pages 219 and 220 of his *Weather Prediction*. How heartily we agree with his final sentence (talking of an imaginary world weather-forecasting office) " Outside are playing fields, houses, mountains and lakes, for it was thought that those who compute the weather should breathe of it freely ".

O. M. ASHFORD

LEWIS F. RICHARDSON, D.Sc., F.R.S.

Photograph by] [*Lafayette*

PLATE I



The R.A.F. Lancaster "Aries I," famous for the investigations of navigational problems near the North Magnetic Pole.

R.A.F. Photograph] [Crown Copyright Reserved

PLATE II

POLAR WEATHER FLIGHTS

By B. C. HAYNES

Chief, Meteorological Observation Section, U S Weather Bureau, Washington, D.C

The North Pole has been the goal of conquest and exploration ever since William Berents made the northward thrust to Latitude 77° 20′ N. at Longitude 52° E. in 1594. During the 16th, 17th, 18th and 19th centuries many attempts were made to reach the Pole, but all were unsuccessful. Robert E. Peary first succeeded in reaching the latitude of 90° North on April 6, 1909. Vilhjalmar Stefansson, a great modern polar explorer, says there are two reasons why men search for the pole: first, to discover short sailing routes across the Arctic Ocean and, second, because of the glamour of reaching a unique point in the Arctic. In his book, *The Friendly Arctic*, he states: "The world in general has imagined the North Pole to be to the Arctic what the mountain top is to the mountain".

Meteorologists have now added a third reason for desiring to reach this special point where all longitude lines converge, and where there is only one cardinal direction —" South ". Meteorology is still in the era of exploration. In studies of the nature of worldwide atmospheric circulation there have always been great blank spaces in the weather maps over the Arctic and Antarctic regions. Because of the long periods of continuous sunshine and darkness at the poles, these regions have special properties with respect to incoming and outgoing radiation. A study of the heat balance in the atmosphere shows that certain areas emit more radiation to space than is received from the sun. In other regions of the earth the opposite is true. A balance is created by the transport of heat through atmospheric movements, or wind. Many theories on the general circulation have been based on incomplete data from the polar regions, and in order to obtain a more complete analysis and understanding of the interchange of air between the equator and the poles, further meteorological explorations and observations are required in the Antarctic and Arctic areas.

In March 1947 the Air Weather Service, meteorological agency for the U.S. Air Force, established weather reconnaissance flights to the North Pole. The flight route, called " Ptarmigan ", followed by the 375th Reconnaissance Squadron VLR (Weather) on a schedule of at least one every other day, originates at Fairbanks, Alaska, extends north-eastward to Aklavik, Canada, thence to Prince Patrick Island, northward along Longitude 123° W. to the North Pole, and finally southward along the 159th West Meridan to Point Barrow, Alaska, and back to Fairbanks. Since inauguration of the Ptarmigan flights, over 100 successful missions have been flown to the Pole with more than 350 persons.

On August 2, 1948, I had the good fortune ot being one of those persons. As Chief of the Weather Bureau's Meteorological Observations Section, I was particularly interested in the detailed methods used by the Air Weather Service in Weather Reconnaissance. Also, as a member of the Polar Commission

of the International Meteorological Organization, I was interested in Arctic and polar meteorological problems and in the state of the ice pack over the Arctic Ocean.

The operational procedures followed by the weather reconnaissance groups are excellent and provide for every emergency. The day before our flight a thorough and complete briefing session was held by the Squadron Commander with the personnel who were to make the flight. Details of navigation, meteorology, radio, and emergency procedures were discussed, and survival clothing and equipment were checked by each member of the crew. I was completely fitted out and, following the briefing session, our equipment was placed aboard the aircraft, a B-29 (Super-fortress) modified to function as a flying weather-observing station. I was instructed on " bail-out " and " ditching " signals and assigned a crash position and " bail-out hatch ".

With all this preparation for an emergency one might think that the crew had great fear of impending disaster. On the contrary, the pilots and airmen who fly the Ptarmigan route have a feeling of security greater perhaps than those who fly the reconnaissance routes over open water. They place a great deal of dependence on the ice field as a place to negotiate a reasonably safe landing and establish a fairly comfortable emergency camp.

On August 2 a bright morning greeted me even though my alarm got me out of bed at 2 a.m. (Alaska Standard Time). By 2.30 a.m.the sun was shining on the snow-covered Alaskan range some 100 miles away, and I was on my way by jeep through the cool, crisp air to breakfast with the crew. Afterwards I accompanied the pilot, navigator, and weather officer to the base operations office, where final clearance papers were prepared for the flight. In the meantime, the co-pilot and crew chief were supervising the pre-flight inspection of the aircraft.

At 4.15 a.m. fourteen of us boarded the B-29, and the four powerful engines were started. At 4.35 a.m. our pilot, Lt. David Laughman, headed our plane down the runway and we were quickly air-borne despite our heavy load of petrol. A gradual climb in a north-easterly direction was made to 18,000 feet. There were only a few clouds, but owing to the low angle of the sun's rays the mountain valleys were still in shadow. We crossed the great Yukon River, passed over the little settlement of Aklavik, Canada, where the Canadian Meteorological Service maintains a radio-sonde station, and thence over the Beaufort Sea. The clear blue water of this part of the Arctic Ocean soon became spotted by ice floes, which at Latitude 72° North joined to form the continuous ice pack.

We flew on the 500-millibar pressure surface and determined its height along our flight track by means of a radio altimeter. Each half-hour a complete weather observation was taken and recorded by our Weather Officer, Lt. L. L. Howes, and radioed back to a land station. "Ptarmigan" weather reports have proved to be highly accurate and of great value to meteorologists stationed throughout North America. Wind determinations were made by the navigators, using visual drift, celestial locations, radio, or radar methods. Temperature, humidity, height of the 500-millibar pressure surface, clouds, and weather were

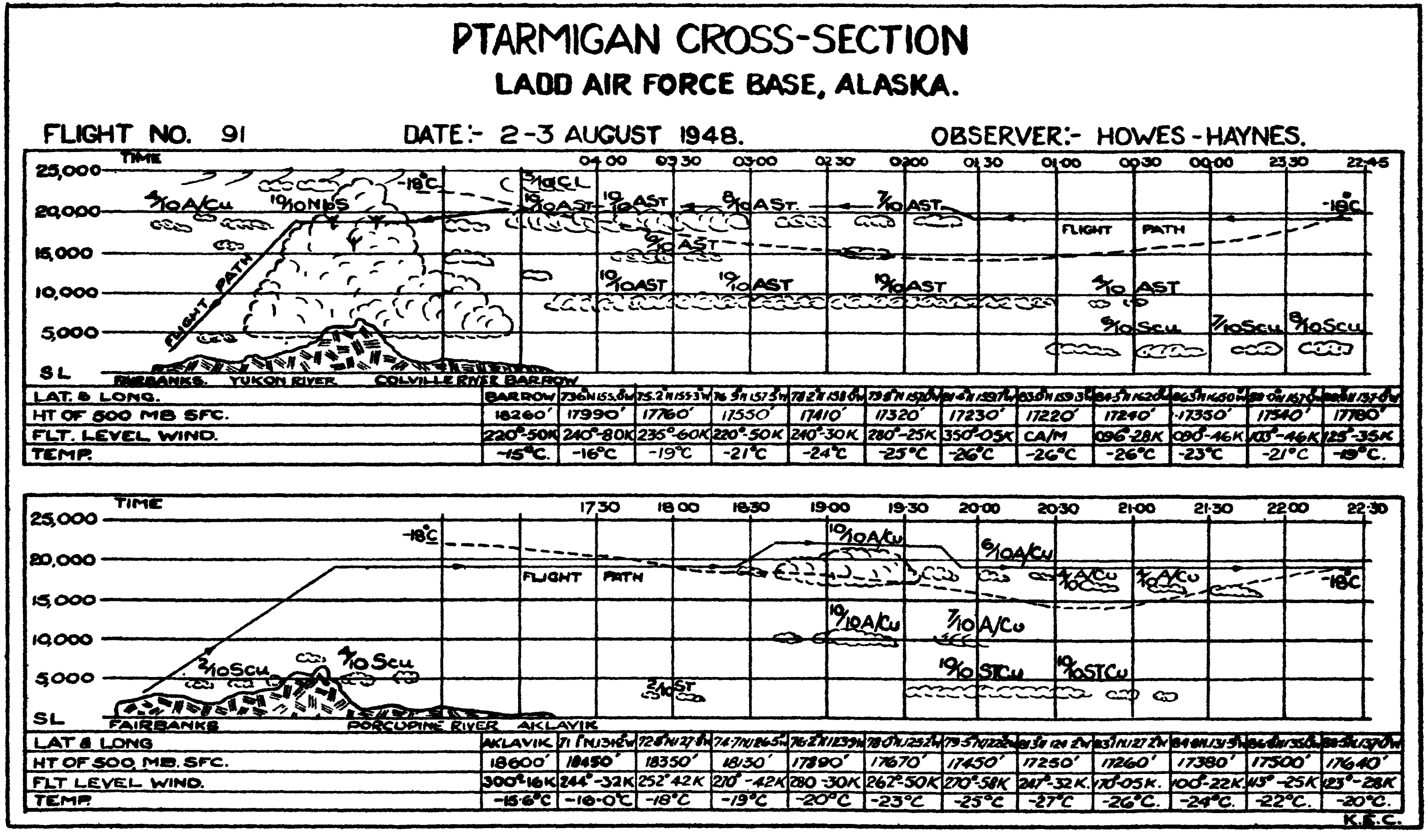


Fig. 1. Cross section along line of flight. Lower half, outward. Upper half, return.

observed by the weather officer.

Before the flight I had set up desired specifications for the weather which would enable me to observe ice conditions in critical areas: first, I wanted clear weather between the continent and the edge of the ice pack—this I had—and second, I hoped that there would be no clouds below our flight level at the North Pole. What happened in between did not matter so long as there was something of meteorological interest to observe.

As we continued north-eastward, a lower cloud layer began to obscure the ice, and this cloud deck was continuous to Prince Patrick Island, which was also obscured. Clouds continued northward from Prince Patrick Island, and at about 80° North I really began to worry about not being able to see the polar ice pack. Occasionally, however, the ice pack was visible through holes in the lower clouds.

We were flying between a broken layer of cirrus clouds at 25,000 to 30,000 feet and a lower altostratus deck, the top of which was estimated at 12,000 feet. At 82° North we could look ahead some 50 miles and see the edge of the lower clouds and the ice pack that stretched beyond to the horizon. We passed the edge of the low clouds and came out over a wide expanse of broken ice. The visibility was excellent, and as we approached the Pole I suddenly realized that I was looking northward across the Pole southward. At 12.30 p.m., Alaska Standard Time (23.30 G.M.T.), the navigators, who had been very busy taking sun lines and drift readings, announced that at 23.50 G.M.T. we would be over the Pole.

Final celestial checks were made at 23.50 G.M.T., and we began a slow circle to the left over the North Pole. At that moment my thoughts were of Peary, Byrd and Amundsen, and of the difficulties and hardships suffered on their expeditions to this lonely " coordinate " of the earth, and of what their thoughts might have been. With modern pressurized and heated aircraft, automatic pilot equipment, and three specially trained navigators using modern grid-system polar navigation methods, reaching the Pole itself has very little meaning. It is merely point X, or the turn-round point for another weather reconnaissance flight. Yet there was a certain thrill in knowing I was there. Everywhere I looked was south. My watch, set to Alaskan time, could not indicate a polar noon or midnight in the usual day, since there is no single meridian, and there is six months of light and six months of darkness. It is indeed a unique point in our usual standards of time and directions.

The ice over the polar sea was broken and looked something like the ice pack I had seen in the Ross Sea on my trip to the Antarctic with the United States Navy's Operation Highjump in January and February 1947. The major difference was the lack of huge ice-bergs over the North Polar region. The North Pole is over a deep ocean and the ice is sea ice which is flat or may become tilted when broken and pushed into pressure ridges by strong winds. There are not direct sources for large bergs, however, on the Arctic coast of North America.

About 50 miles south of the Pole on our homeward flight in the direction of Point Barrow, Alaska, low cloud layers again obscured the ice. From this

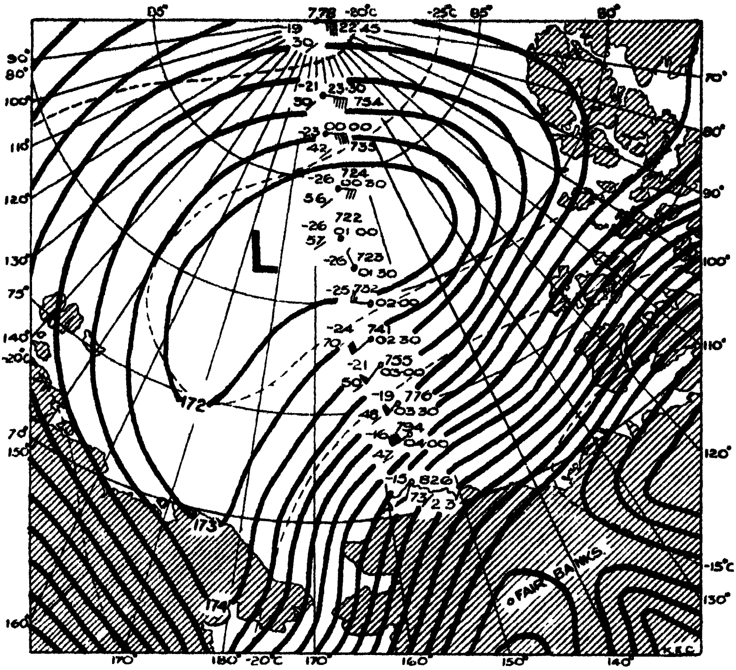


Fig. 2. 500 mb. chart with observations along line of return flight.

point southward we experienced about every type of weather that could be expected at our flight altitude. The 500-millibar surface on which we were flying lies at about 18,000 feet above sea level. Half of the atmosphere lies below this level and half above. We were not in the stratosphere, however, as its base was about 10,000 feet above us. The cirrus clouds we observed above us were near the base of the stratosphere.

We passed through a series of cloud bands, each about 50 miles wide and extending in an east-west direction as far as we could see. The temperature at flight level was $-4°$ F., and each cloud we passed through deposited ice on the aircraft. This indicated that the clouds were composed of water droplets which had been cooled far below the normal freezing point (32° F.) for water.

As we approached the coast of Alaska we encountered continuous clouds, and after taking the last scheduled reconnaissance observation the pilot therefore climbed to 19,500 feet to try to avoid further icing. Icing continued, however, and chunks of ice flung from the propeller blades sounded like brick-bats striking the fuselage. We then decided that a descent to lower levels would bring us into above freezing temperatures. At 13,000 feet the ice, which was about half-an-inch thick on parts not protected by de-icers, began to melt oft. A smooth descent and perfect landing were made by our pilot at Ladd Air Force Base, Fairbanks. We taxied to the parking area at 9.10 p.m. Alaska Standard Time. We had been aloft 16 hours 35 minutes, and a tired but alert Weather Reconnaissance crew were glad to have chalked up another perfect Ptarmigan.

ON THE GENESIS OF A DUST WALL

By E. DESMOND and U. RADOK

Among the various types of dust storms described in the meteorological literature, special interest attaches to that in which the dust is carried along in the form of a dust wall. Details of the accompanying flow were established by Koschmieder (1939, 1946) from observations of the sea breeze, a similar phenomenon. Both represent essentially shallow bodies of cold air moving as a whole with a speed greater than that of the surrounding warmer air but in general with less than the speed of the flow in the cold air itself. This requires the existence of upward motion near the leading edge in the cold air itself and leads to a modification of the traditional cold front model according to which the upward motion takes place merely in the warm air.

While in the case of the sea breeze the origin of the cold air is obvious, some doubt exists regarding its nature in the case of dust walls. According to Koschmieder, dust walls are invariably connected with cold fronts. Experience in SE. Australia shows, however, that they frequently occur in the region of strong northerlies ahead of a cold front and at times precede the passage of the latter by several hours. In such a case the forecaster may be induced to draw a minor front ahead of the main one, and this interpretation will be rendered even more plausible by the fact that in this region genuine cold fronts frequently show few or none of the condensation phenomena associated with most cold fronts in temperate latitudes, owing to the shallowness of the cold air and the extreme dryness of the prefrontal tropical continental air.

The purpose of this note, on the other hand, is to present observations of a dust wall which appeared to arise from a local instability phenomenon moving in the northerly flow. This view will be based in particular on an aerological sounding which was obtained by one of the authors (E. D.) in a flight through the dust wall itself, after its actual genesis had been observed from the air.

The storm in question was encountered on December 30, 1947, in the course of a study, reported elsewhere (Radok, 1948), of convective gusts by means of sailplane flights at the Christmas camp of the Gliding Club of Victoria at Benalla, Victoria. As that study did not provide for regular ground observations, surface conditions will be illustrated, where required, by autographic records obtained at neighbouring stations, placed at the authors' disposal by courtesy of the Commonwealth Meteorological Bureau, Melbourne.

The 3 a.m. weather chart of December 30 showed a disturbance of 996 mb. west of Adelaide which moved SE. along the continent and Tasmania during the day. The morning sounding at Benalla (obtained, as all following, by means of a Tiger Moth aircraft carrying a Friez meteorograph) is shown as curve A in Fig. 1. The ground inversion disappeared before 8 a.m. and strong gusty northerlies set in which lasted throughout the day. The temperature rose rapidly to 32° C. at 10.40 a.m. and 35° C. at noon, after which, as expected from sounding A, clouds soon formed; their base appeared to be at approximately 14,000 ft. and precipitation was observed to fall out of them, without reaching the surface.

At 3.30 p.m. the temperature had risen above 37° C. and the clouds had taken on a much thicker appearance. It was then decided to undertake a further sounding, and to investigate in particular any regions of precipitation near the cloud base.

The resulting ascent is shown in Fig. 1, curve B. A slightly super-adiabatic lapse rate existed at the time up to the maximum altitude reached, 11,600 ft. The accuracy of the meteorograph temperature record seems established beyond doubt by the fact that strictly dry-adiabatic lapse rates were invariably recorded with the same instrument by ascending sailplanes. The relative humidity showed surprisingly little variation throughout this flight, although on other occasions the hygrograph element was found to be fairly sensitive.

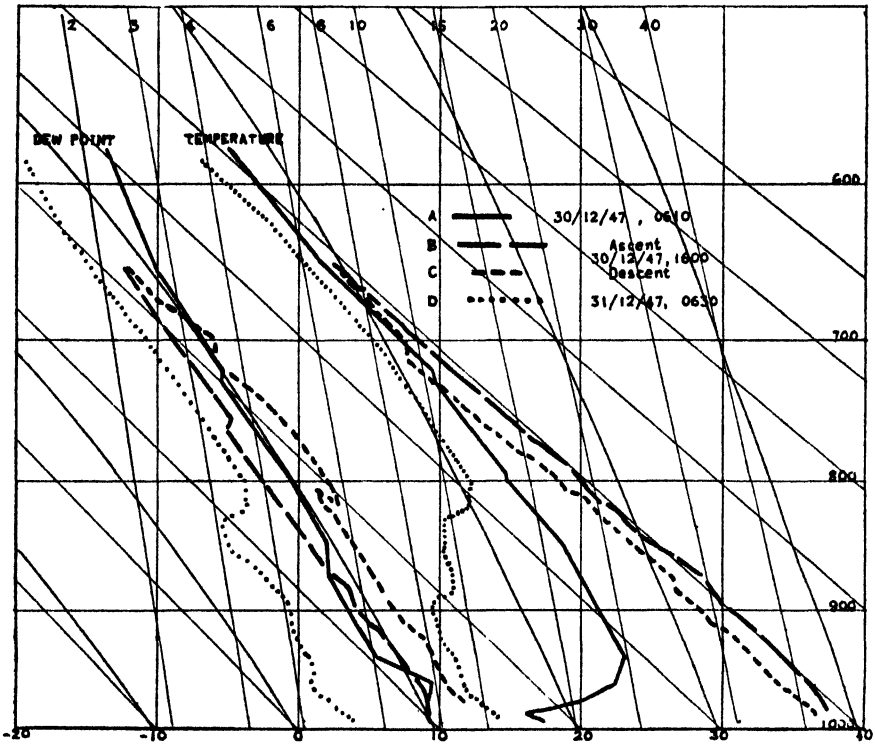


Fig. 1. Upper-air soundings at Benalla.

No precipitation was visible anywhere in the early stage of the ascent. Then, at 3.37 p.m., dust began to rise in three large areas on the ground, as though the speed of the surface wind had undergone a sudden increase. These areas extended several miles each across the direction of the wind (NNW.).

A few minutes later (after a drift determination of the wind at 6,000 ft. which showed it to be 335°, 45 m.p.h.) a distinct lowering of the cloud base had become visible in the same region which appeared much darker than the rest of the cloud. From this depression in the cloud precipitation was now streaming down and disappearing behind the rising dust.

Flying towards the phenomenon the aircraft crossed a large area of descending motion which at a distance of about 4 miles from the region of precipitation gave way to an equally pronounced field of strong and steady lift. The dust had by now risen to 4,000 ft. and gave the impression of being caused by a flow converging at some focal point at the rear of the wall, the leading edge of which was spreading out in a markedly fan-wise manner.

Some of the streamers of precipitation turned out to be composed of small snow-flakes (about $\frac{1}{8}$ in. diameter), others of rain. Large temperature changes occurred between the two, which, however, did not appear in the temperature record.

In the region of the depression in the cloud base from 12,000 ft. to 10,000 ft. the air was completely smooth. Further to the rear of the is turbance very intense turbulence was encountered, and further still a largedfield of down-draughts of the order of magnitude 40 to 50 ft./sec. (estimated from the rate

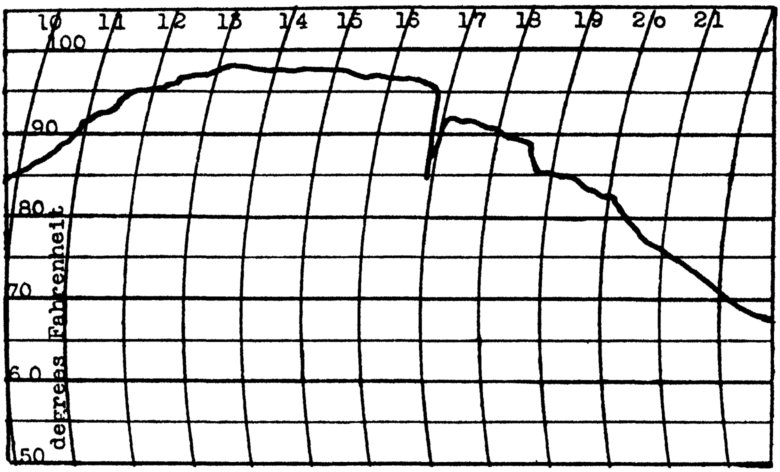


Fig. 2. Temporary cooling at Tatura at 16.50 h. towards the rear of the disturbance.

of descent and the fact that the aircraft was flown with climbing speed and revolutions). On turning back to regain height a number of similar walls were observed in the distance, in addition to the two which had formed alongside that traversed.

The edge of the dust wall passed over Benalla aerodrome at 4.12 p.m., which puts its speed of translation at 20 to 25 m.p.h.—roughly the speed of the undisturbed northerly flow. At 5,000 ft., just inside the dust, marked rising motion was experienced in a wind of approximately 65 m.p.h. At the surface, wind measurements in a subsequent dust wall at 5.40 p.m., which closely resembled the first, showed gusts to 40 m.p.h. Inside the dust at the surface a dark yellow light prevailed and the visibility was restricted to a few hundred yards. The temperature appeared little changed, but towards the rear of the disturbance a marked cooling occurred which lasted about two minutes and was accompanied by a few scattered rain drops. A good illustra-

tion of this cooling is shown in Fig. 2, giving the temperature record obtained on the same day at Tatura, 43 miles W. of Benalla. The phenomenal drop in

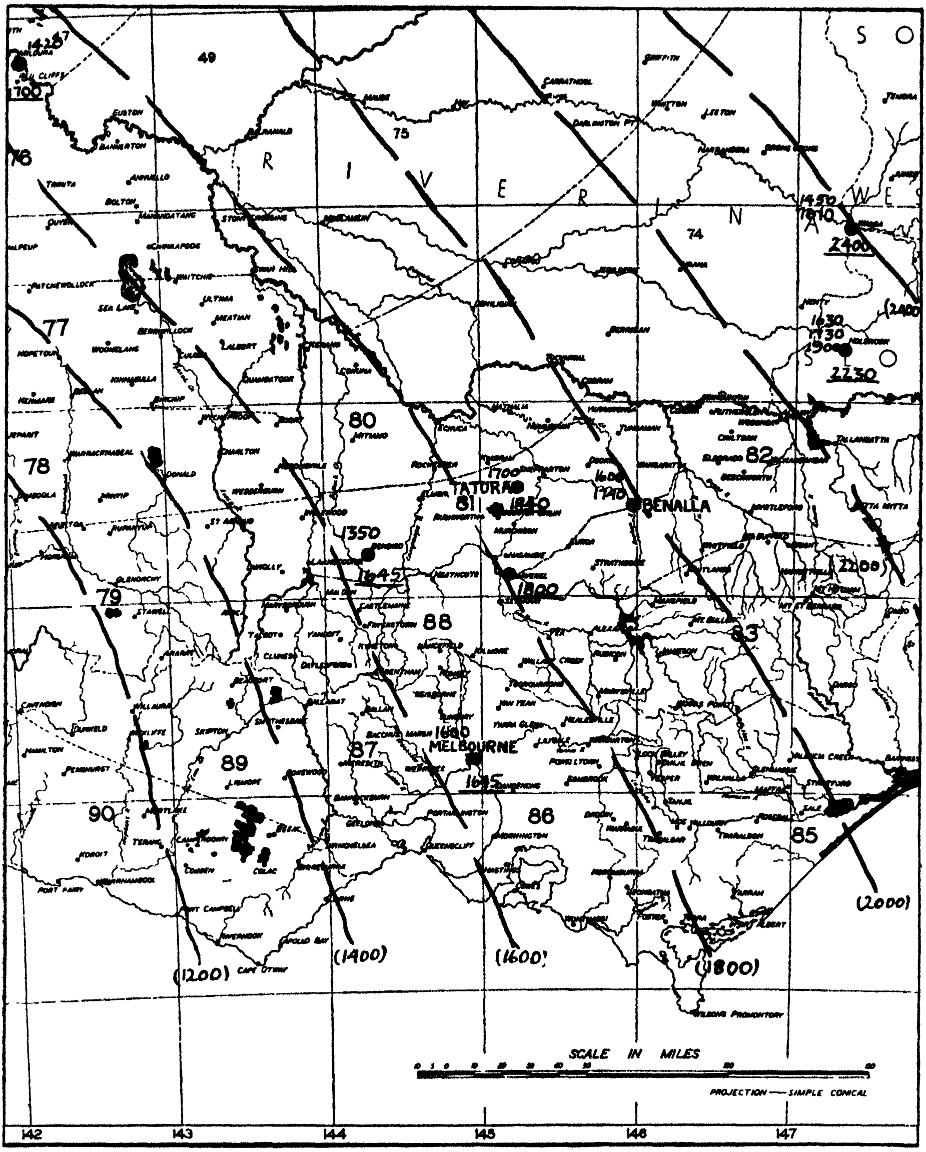


Fig. 3. Times of passage of the front.
The numbers underlined, and the isochrones, show the times of passage of the front. The plain numbers are the observed times of dust disturbances.

temperature is probably explained by the presence of snow which at Benalla was observed down to at least 2,000 ft.

From the above description it seems likely that this particular dust wall

arose from a local accumulation of cold air which had been cooled below the temperature of the unstable environment by moist-adiabatic descent. The immediate cause of its descent is not clear from these observations. However, the fact that the lowering of the cloud base did not appear until several minutes after the increase in surface wind and the initial rising of the dust would suggest that the disturbance started in the air immediately above the highly unstable surface layer and from there spread to higher levels.

The ratio of the speed of translation to the speed of the flow in the cold air agrees very closely with the value of one half, deduced theoretically by Prandtl (1939) for the case of small density differences between the cold and the warm air. For the sea breeze, Koschmieder found a slightly larger value which may be due, at least partly, to the considerably larger temperature differences involved.

A comparison of the ascent (B) with the descent (C) is rendered difficult by the fact that the first part of the descent, to just below the 800 mb. level, was much more rapid than the remainder. In consequence the humidity registration seems likely to be too low, resulting in an increase in the lapse rate of the pseudo-potential temperature rather than the decrease to be expected from the " overturning " process. On the other hand the possibility cannot be excluded that the entire phenomenon, being of a largely local character, left no lasting mark on the stratification of the surroundings.

The sounding obtained on the morning of the following day (Fig. 1, D) shows a pronounced change in air mass up to the 800 mb. level. The front appears to have passed Benalla some time after 7 p.m. on December 30th. This time is suggested by Fig. 3, where a comparison is given between the times of disturbances, similar to that experienced at Benalla, and the time of passage of the front (underlined), the latter being marked by a strong and sustained pressure rise. Tentative isochrones have been drawn for this frontal passage, whereas it is clear that the times of the disturbances cannot be combined in this way. This confirms the view of the latter as local convection phenomena of unusual proportions, arising from a combination of unstable equilibrium in lower layers and cooling by moist-adiabatic descent above.

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ROYAL METEOROLOGICAL SOCIETY NEWS

The second of the series of popular meetings arranged by the Council of the Society was held on Friday, December 3, in the Lecture Theatre of the Science Museum. The Chair was taken by Dr. J. S. Forrest, who explained that, while the other meetings in the series would consist of lectures by eminent meteorologists, this second meeting would be devoted to an exhibition of films illustrating the use of ciné-film technique for instruction and research in meteorology. The first two films in the programme, British Meteorological Office instructional films, entitled " Synoptic Meteorology " and "Fog " were introduced by Dr. J. S. Farquharson, who had been closely concerned with their production. " Synoptic Meteorology ", a 16 mm. black-and-white sound film, gives a graphic picture of recording instrumental observations, reporting data, and drawing the weather chart : the various types of pressure distribution are also described. " Fog ", also a 16 mm. black-and-white sound film, is primarily intended to warn the pilot of the dangers of fog ; it shows some elementary experiments illustrating the physics of fog formation and describes the different kinds of fog the pilot may encounter. Dr. Farquharson, commenting on these films, pointed out certain changes which had taken place since the films were made ; for example, the use of ocean weather ships and changes in meteorological codes.

The third film, an American Kodak 16 mm. silent film in Kodachrome, illustrated the use of " time lapse " technique, that is, the opposite of slow motion—pictures are taken at a speed of about one per minute and projected at sixteen per second, so that the motion is apparently speeded-up about a thousand times. This film showed pictures of the whole sky for several typical summer and winter days and nights, and gave a most impressive picture of cloud development and turbulent motion. The occurrence of solar and lunar halos was noted by the audience.

Finally, Mr. O. M. Ashford showed a 16 mm. black-and-white silent film which he had recently photographed on board a weather ship. This film showed the launching of radiosondes under difficult conditions and a practice air-sea rescue. Some amusement was caused by a shot showing a wind-vane rotating continuously like a cup anemometer.

Post-Glacial Climatic Change

After seeing over Mt. Wilson Observatory, Mrs. Einstein was told, in answer to a question, that the magnificent apparatus was for the study of the heavens and the working of the universe. " Good gracious me ! " she said, " My husband does that on the back of an old envelope ". Although it made less progress than either Einstein or the Mt. Wilson Observatory, the Society had the feeling that it was studying the universe when it met, jointly with the Royal Astronomical Society, in the excellent lecture room of the Science Museum, South Kensington, on December 15.

Dr. Hoyle opened the discussion by considering whether the sun could change rapidly enough to be a possible cause of post-glacial climatic changes. He thought not, but the sun was continually sweeping up material, such as hydrogen, from interstellar space : and in falling into the sun this material acquired enough energy to emit ultra-violet radiation. If the solar system were to pass through one of the regions where interstellar matter was more dense than normal it could have an important effect on climate.

Dr. Godwin, a past president of the British Ecological Society, told how pollen in sedimentary deposits at Hockham Mere, Norfolk, indicated the gradual warming of the earth after the ice age, with an optimum period between 6,000 and 3,000 B.C., followed by some deterioration. The trees whose pollen had been used as an index of temperature ranged from birch (cold), through pine, elm, oak, to lime and alder (hot). Ivy, holly and mistletoe could be used to indicate whether the annual range of temperature was great or small, i.e., whether the climate was continental or maritime.

Professor Manley showed that instrumental records indicated a rise of about 3°F. since 1750 A.D., and claimed that this had been due to an increase in the "stirring" of the atmosphere. Dr. C. E P. Brooks referred to changes in the inclination of the earth's axis, and variations in the arctic ice cap. If the north-polar ice broke and drifted south, the tracks of cyclones were pushed south with a marked effect on weather.

Dr. Atkinson, as an astronomer, was sceptical of the interstellar clouds as an explanation, but thought biological factors should not be overlooked. He mentioned the Sargasso Sea and the Gulf Stream, but Dr. Deacon, for the oceanographers, was not keen on this as a *primary* cause of climate, since it depended largely on wind direction. He thought calcium deposits at the sea bottom might be studied.

Mr. Gold told a fishy story with a moral, and Mr. Schove proved that periods of war caused droughts in China. Volcanic activity and statistical theory were talked about learnedly, but the meeting ended with a feeling of doubt. Perhaps it would have been better either to narrow the scope of the discussion, or to study the universe from not quite so many angles.

SCOTTISH CENTRE

A meeting of the Scottish Section was held in the Department of Natural Philosophy, Edinburgh University, on Wednesday, December 15, at 7.30 p.m. Sir E. M. Wedderburn presiding. Mr B. V. Bishop, who had been Meteorological Officer at Turnhouse for some years, spoke on the local weather peculiarities of Edinburgh and the problems of forecasting for it and the surrounding district.

He discussed special features of the local weather from the point of view of the practical forecaster and offered explanations of them. He pointed out that the most important factor determining local weather is the behaviour of the local surface winds with respect to the upper winds, and stated that the predominant direction, W.S.W., is more marked here than for predominating winds at other stations in Britain.

With reference to visibility, it appears that "Auld Reekie", though smoky, does not suffer from the worst effects of pollution in the way of real "urban gloom", which is more common in London and other large cities. Dense fog is infrequent and seldom dislocates surface traffic. Our heaviest falls of precipitation accompany easterly winds, while our thunderstorms are mostly brewed in England !

Finally, he gave a detailed account of the development of the haar and offered hints to assist the forecasting of its behaviour. (EDITORIAL NOTE : According to the Meteorological Glossary, "haar" is a local name in eastern Scotland and parts of eastern England for a kind of wet sea fog which at times invades coastal districts. It occurs most frequently in summer.)

Will Members please note that on Friday, February 18, at 7 p.m., a meeting is to be arranged at Edinburgh University when meteorological films will be shown.

MIDLAND CENTRE

At the opening meeting of the Midland Section on September 28, 1948 the lecture given by Mr. W. H. Smith, A.R.I.C., F.R.Met.S., bore the somewhat intriguing, if unusual, title " Bakers ! Watch the weather ".

Mr. Smith, who is Chief Chemist and Manager of Messrs. C. B. Elkes & Sons, Ltd., Biscuit and Cake Manufacturers, Uttoxeter, gave a survey of how the baker and his work are affected by weather to an extent that it would appear that climatology is a very direct concern of the baker who desires constant quality reproduction.

The lecturer dealt with the indirect influences of weather on the growing, harvesting and storage of the raw materials, correlated with subsequent bakery processing. As an example, samples of the same species of wheat grown under different weather conditions were shown and their differences discussed. A more extensive survey was given of the more direct weather influences, especially regarding buildings, raw materials and product storage, processing, packaging, transport and shelf-life ; even van construction from the weather angle was mentioned.

It was explained how the combining of cake mixes and the final product were swayed by weather factors, even to altitude at which the cake was made affecting cake volume. Bacterial and mould growth, insect and rodent infestation are also affected by weather.

Samples of chocolate biscuits made under excellent and adverse humidities and temperatures were exhibited to emphasize the importance of such conditions.

The lecturer's quotation from Goethe, " Nature is infinite, but he who takes note of symbols will understand many things—but not altogether ", applies to this and, we fear, other aspects of meteorology.

OUR CHANGING CLIMATE

On Friday, October 29, the Midland Centre held a particularly large and successful meeting. Professor Gordon Manley, M.A., M.Sc., gave a lecture entitled " Is our climate changing ? " He began by recalling our well-known tendency to remember occasional extreme events and forget the average. Further, as a result of migration since the industrial revolution, 80% of our population now live in towns, and their impression of winter weather in particular is affected by the appreciable " urban effect " on the incidence of frost and snow. But when all allowances are made, and disregarding individual winters in favour of the general trend, there has been a slight but definite overall tendency in the direction of milder winters since about 1850 or earlier.

Ten-year running means of temperature for winter months in Sweden, Holland, and England show this. Scandinavian glaciers are retreating, and the area of Arctic sea-ice has also decreased. The vegetation of Iceland and Norway is believed to have been affected by these changes, but not, apparently, that of England.

We cannot set a term to this trend ; may be it is already on the turn. From time to time since about 3,000 B.C. deterioration has occurred and been followed by some recovery. Summer temperatures have remained much the same ; in some districts precipitation may have slightly increased, but elsewhere it has not.

Taking summer and winter together, we may conclude that a slight amelioration has occurred ; but to the average Englishman the artificial effects of the growth of towns, better drainage and transport, and more shelter in gardens, are far more noticeable.

LOCAL WEATHER

Despite the particularly low temperature, and fog that was almost thick enough to stop traffic, nearly fifty Fellows and friends attended a meeting of the Midland Centre at the Birmingham University at 7.15 p.m., on November 30, 1948, when Commander C. R. Burgess, O.B.E., R.N., spoke on "Local Weather". He began by defining his subject as, broadly speaking, the modifications that must be made to a regional forecast to allow for the effects of solar and terrestrial radiation and also of relief and topography; the keen amateur can often successfully supplement a forecast by the B.B.C. or Airmet, if he considers the principles upon which these effects depend and applies them to his own immediate locality. The lecturer went on to show some of the ways in which several elements of weather are affected including, for example, the diurnal variation of wind speed and direction over land and coastal regions, the diurnal variation of low cumuliform and stratiform cloud, advection and radiation fog, the sheltering effect of high ground on wind, cloud, rainfall and advection fog. Reports on the local weather characteristics of several airfields in the British Isles were quoted and some slides shown to illustrate some of the points made. The Chairman, Mr. A. L. Kelley, who had made an especially interesting contribution, closed the meeting at 9 p.m.

FORTHCOMING MEETINGS

On January 12, at 6 p.m. in the Lecture Theatre of the Science Museum, Exhibition Road, South Kensington, Sir George Simpson, F.R.S., ex-Director of the Meteorological Office, will give the next of the series of popular lectures. He has chosen for his subject "Atmospheric electricity during the last 50 years", and Sir Robert Watson-Watt, F.R.S., will be in the Chair. On February 10, also at 6 p.m. in the Science Museum Lecture Theatre, Sir Nelson Johnson, Director of the Meteorological Office, will give a lecture on "Some international aspects of meteorology", and Mr. E. Gold, F.R.S., for many years Deputy Director of the Meteorological Office will take the Chair. Non-members are especially invited to these popular lectures.

The Annual General Meeting will take place in the Society's rooms at 5 p.m. on Wednesday, January 26, when Dr. G. M. B. Dobson, F.R.S., will deliver the Presidential Address on "Ice in the atmosphere".

The attention of members is directed to an informal dinner to be held at 7.30 p.m. on January 26, 1949, at the Glendower Hotel, 9, Glendower Place, S.W.7 (a few minutes' walk from the Society's Rooms). The cost, inclusive of drinks and gratuities, will be approximately 9/-. Will any member wishing to be present please inform the Assistant Secretary by the 21st, indicating whether he (or she) intends to bring a guest.

It has been proposed that a Dining Club should be constituted with the object of providing regularly, after meetings of the Society, a dinner at which foreign or other distinguished guests may be entertained; the suggested annual subscription is 10/-. The proposal will be explained at the A.G.M. and will also be discussed at the dinner following this meeting.

At the Ordinary Meeting on February 16 there will be a discussion on "Large-scale vertical motion in the atmosphere" when recent papers by J. K. Bannon, B.A. and R. C. Graham will be referred to (See *Quart. J. R. Met. Soc.*, Vol. 74, p. 57, and Vol. 73, p. 407).

The next Meeting of the Midland Centre will be held in the Lecture Theatre of Birmingham University, Edmund Street, Birmingham at 7.15 p.m. on Tuesday, January 25, when Dr. J. Glasspoole, M.Sc. will give a lecture on "The development of our knowledge of rainfall over the British Isles during the last 30 years".

METEOROLOGICAL INSTRUMENTS

A RATE OF RAINFALL RECORDER

Recording rain gauges at present in use by the various Meteorological Services are usually based on the principle of collecting the precipitation through a funnel in a chamber and recording the depth of water by various means. A record is obtained of the amount of rainfall as a function of time. One can, of course, read off the quantity which has fallen since the beginning of the record, but it is not possible to measure the rate of rainfall at any moment accurately. When the rate of fall is small, it is easy to draw a tangent to the curve at a given point and hence find the rate, but when the rain is heavy the slope of the curve is so steep that it gives rise to considerable errors. Sometimes the curve is nearly perpendicular to the time axis, so the record gives an inadequate impression of the structure of frontal rain, heavy showers or rainfall in thunderstorms.

The recorder here described gives an immediate idea of the variations of rain intensity for various types of rainfall. The principle is illustrated in Figure 1. The water passes through the funnel *D* into a bucket *A*, which is

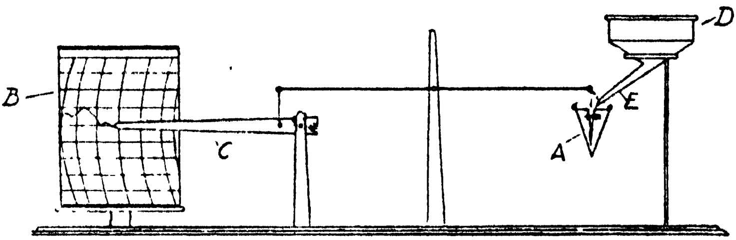


Fig. 1. Sketch illustrating the principle of the rate of rainfall recorder.

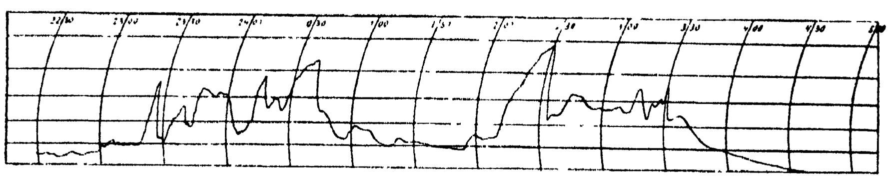


Fig. 2. A continuous record of the rate of rainfall at Voorschoten on October 3–4, 1938, during the passage of a depression

suspended on a lever balance which moves the recording arm *C*. The pen rests on the chart which is mounted on a clockwork-driven drum *B*. When the bucket is empty, the pen is on the zero line, and as the rain enters the bucket its weight increases, the lever dips and the pen moves up the chart. Water runs out of the bucket through a slit in the wall, and as the water covers a longer length of the slit it will be able to run out more quickly. As long as more water enters the bucket than runs away, the surface of the water rises and the bucket becomes heavier. With a steady rate of rainfall, the depth of water in the bucket will increase until equilibrium is established. Thus any

given rate of rainfall corresponds to a given depth of water in the bucket and to a certain height of the pen. If the rate of rainfall increases, the surface soon rises to a new equilibrium position ; every change of intensity is recorded within a few seconds. The instrument is calibrated direct in terms of rate of rainfall.

The specimen record shown in Figure 2 shows how easily the rate of rainfall can be read off at any moment. Hitherto we have not been able to measure the rain intensity accurately in Holland ; sometimes the rate has been measured over a short space of time, but this only gave the *average* rate over, say, five or ten minutes. Peak values had to be estimated. With the new gauge, the rate is given accurately without the necessity for any calculation. The record illustrated was obtained during the passage of a well-developed depression.

Many records have been obtained with this gauge in the past few years and it has always functioned satisfactorily. The manufacturers of the gauge also supply instruments for calibration. The usual chart runs for 36 hours. A totalizer can be supplied by means of which all the water can be collected for measurement.

The rainfall recorder is covered by Patent No. 88967 in the author's name.

CHR. A. C. NELL, Voorschoten, Holland.

(An account of this instrument was first published in *De Natuur*, No 6, June 1939
EDITORS.)

BIBBY RATE-OF-RAINFALL RECORDER

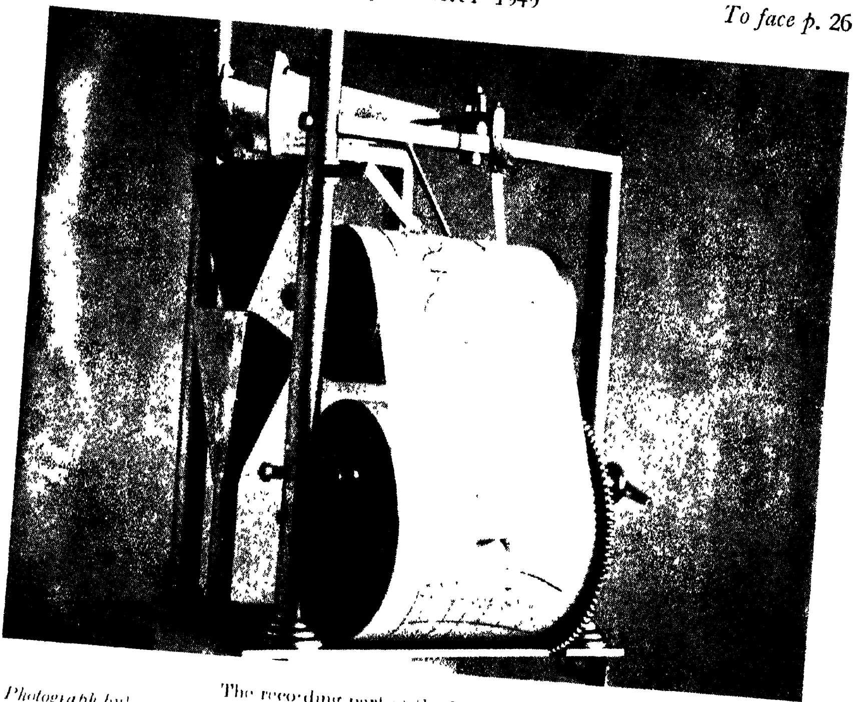
It is interesting to compare the instrument described in the above article with the Bibby Rate-of-Rainfall Recorder (see Quarterly Journal R Met Soc., October 1944, page 277), a more recent form of which was demonstrated at the Annual Instrument Exhibition of the Physical Society in April, 1948. In this instrument, each drop of water falling from the collector of the rain guage hits a lightly balanced " paddle " which makes an electric contact, and the recorder, illustrated in Plate III, shows in effect the number of contacts made in each successive interval of one minute or three minutes. The charts are calibrated direct in terms of rate of rainfall.

PROFESSOR D. BRUNT, SEC. R.S.

Readers will be interested to learn that Professor Brunt has been elected to succeed Sir Alfred Egerton as Secretary (Physical Sciences) of the Royal Society. This onerous office is held for ten years, and involves service on the main scientific committees of the country. We wish him a happy and fruitful decade.

SIR ROBERT WATSON-WATT : HUGHES MEDAL

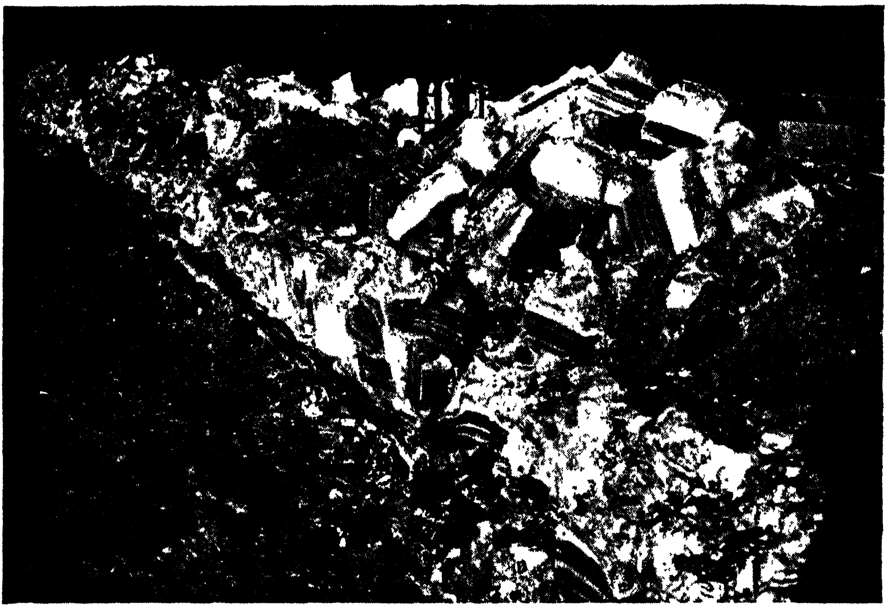
We offer our congratulations to Sir Robert Watson-Watt on the award of the Hughes Medal of the Royal Society in recognition of his researches in atmospherics and radar. He developed the Sferics technique for the location of thunderstorms and led the earliest British work on radar. He is now engaged in the peace-time applications of radar, especially for civil aviation.

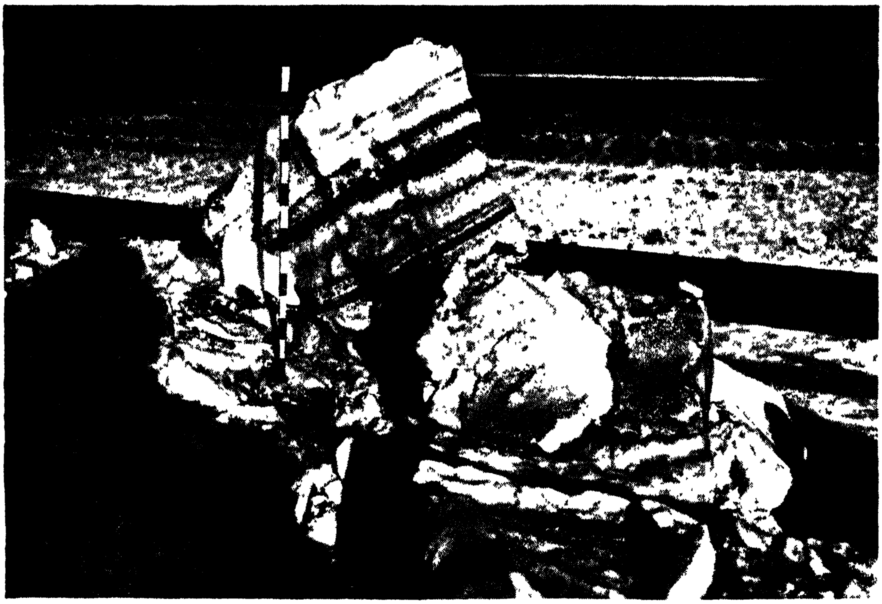


Photograph by] The recording part of the Nell raingauge [*Chr. A. C. Nell*

The Bibby Rate-of-Rainfall Recorder.

PLATE III.





The "confectionery" effect in the above photographs of snow cleared from a path, taken near Middlesbrough in February 1940, is due to a series of strong winds which swept up light powdery snow and dust from the ploughed field. The scale in the lower picture is in inches.

Photographs by] [*Cleveland H. Hood*

PLATE IV

HEBRIDEAN SNOWFALL

A COMPARISON WITH THE EAST COAST OF SCOTLAND

By DONALD L. CHAMPION

It is a popular fallacy of the average Englishman to consider winters in the Hebrides as bleak and icy. Show him a map of winter isotherms and he will still shake his head in doubt. The frequent mention in winter weather forecasts of depressions approaching the Hebrides from Iceland may give rise to the association of Hebridean with Icelandic weather. The marked deficiency of snow in the Hebrides when compared with the east Scottish coast, as shown by the following data, may help to place the Hebridean winter in correct perspective.

This article is based on data extracted from the *Monthly Weather Report* for the winters 1935–6 to 1946–7 inclusive, from the following stations :—

HEBRIDES	EAST COAST
Stornoway	Wick
Barra	Aberdeen
Tiree	Arbroath
Colonsay	Dunbar

These stations were selected in order that those on the east coast should be in approximately the same latitude as their corresponding stations in the Hebrides, the latter being on islands well separated from the mainland. As a point of interest data are included from Dalwhinnie, a high-level station in the central Highlands.

Histograms showing the mean seasonal number of snow-days and days with snow lying at each station, together with a map showing their relative positions, are given in Figure 1. The winter season is defined as the period of eight months from October 1 to May 31 in the following year.

It will be seen that the number of snow-days in the Hebrides and on the east coast decreases with decreasing latitude, but in each case at the same latitude the number of snow-days is considerably less at the Hebridean stations. Stornoway averages 28 snow-days per season and Wick 43, whereas Colonsay has but 7 snow-days and Dunbar 16. In marked contrast, Dalwhinnie averages 52 snow-days per season. The seasonal number of days with snow lying shows similar characteristics, though Wick has 19 days against 22 at Aberdeen. In the Hebrides the number of days with snow lying falls from 12 at Stornoway to only 3 at Tiree, but at Colonsay, the most southerly of the Hebridean stations, the number of days with snow lying is higher, averaging 6 per season. It is a curious anomaly that Colonsay having but half the number of snow-days as Tiree, should have twice the duration of snow cover. It will be noted that at Dalwhinnie the duration of snow cover is 61 days, exceeding the number of snow-days by nine.

The mean monthly distribution of snow-days and days with snow lying for these stations is shown in Figure 2. From these histograms it will be

seen that by far the greater snowfalls occur in the months of January to March inclusive, with January as the peak month at every station except Barra where the maximum number of snow-days occurs in February. During the period under review, it is of interest to note that no snowfall was reported during the month of October at Tiree and Dunbar and November at Colonsay.

The monthly duration of snow cover is shown by the super-imposed shaded columns in Figure 2. At most stations the variations in the number of days with snow lying tends to follow the number of days of snowfall, but at Tiree and Colonsay there is a secondary minimum in the month of February. At all Hebridean stations except Colonsay the number of days with snow lying

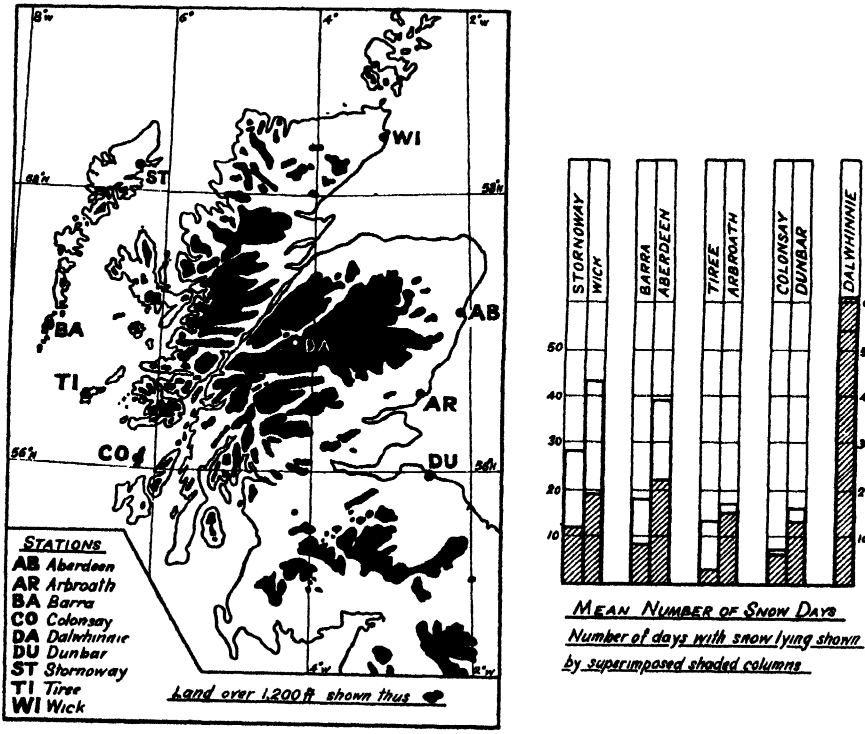


Fig. 1. Mean snow-days and days with snow lying for stations shown on map—October to May.

is considerably less than the number of snow-days. At Colonsay, however, days with snow lying exceed the number of snow-days in January and March, and in each month from December to April the period of snow cover exceeds that of Tiree. At east coast stations, days with snow lying exceed the number of snow-days in February and March at Dunbar, and in February at Arbroath. Snow lying has been reported in every month from October to May at Aberdeen. At Dalwhinnie snow cover exceeds days of snowfall from December to March, reaching a peak of 17 days in January. From the above data it will be apparent that the Hebrides have little snowfall when compared with east coast stations, and that, as would be expected, the high-level station at Dalwhinnie has by

far the greatest snowfall. Tiree appears to be the most snow-free of the Hebrides, with less than five snow-days, on the average, in any month.

Why does snowfall remain twice as long on Colonsay as on Tiree when the latter has twice as many snow-days ? A possible solution may be apparent from the geographical position of Colonsay. It will be seen from the map (Figure 1) that at Tiree all snow-bearing winds with an easterly component have to cross the mountainous mainland of Scotland, thus being forced to precipitate much of their snowfall and, on descending to sea-level, are then

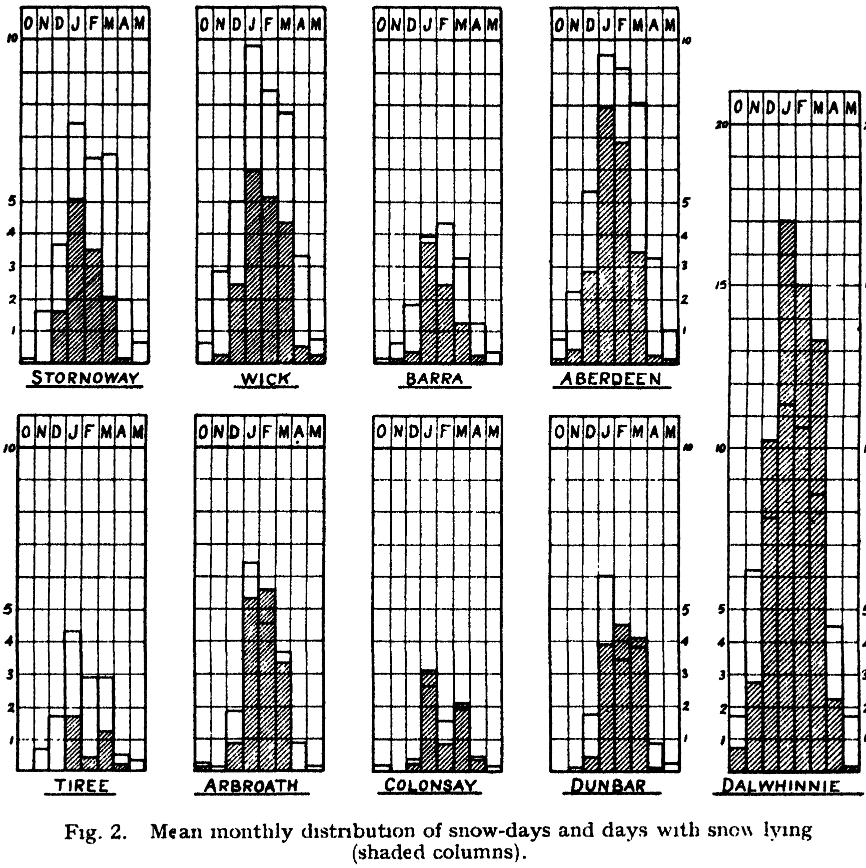
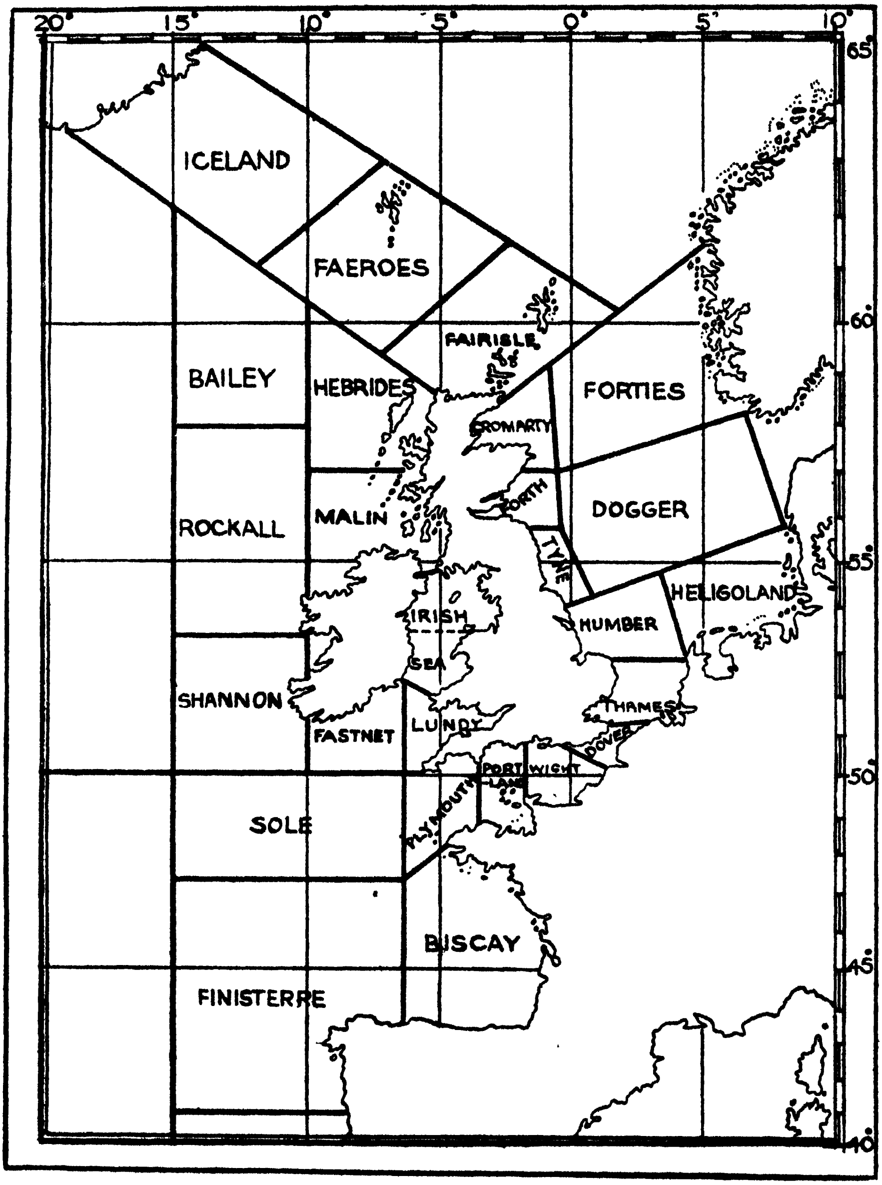


Fig. 2. Mean monthly distribution of snow-days and days with snow lying (shaded columns).

warmed adiabatically, reaching Tiree relatively warmer and drier. This also applies to Colonsay with one marked exception. North-easterly winds can blow straight through Glen More and down Loch Linnhe and the Firth of Lorne, reaching Colonsay without having to cross any high ground. Snowfalls on Colonsay followed by a north-easterly wind would therefore be subjected to a colder and more humid air current, and thus thaw or evaporate much more slowly than similar falls on Tiree or Barra.

Thanks are due to Dr. J. Glasspoole of the Meteorological Office for assistance in the preparation of this article.

AREAS USED IN GALE WARNINGS AND WEATHER BULLETINS FOR SHIPPING FROM NOV. 1, 1948



VACANCY

Applications are invited for a Secretarial Post in the Royal Meteorological Society for scientific sub-item editing, book-keeping, minutes, etc.

Salary according to qualifications. Apply to Hon. Secretary, Royal Meteorological Society, 49 Cromwell Road, London, S.W.7.

THE WEATHER OF DECEMBER 1948

VERY MILD AT FIRST, COLD LATER

Perhaps the most remarkable feature of the month was the persistently mild weather during the first fortnight; except for a brief interval from 4th to 5th, the average temperature at Kew was nearly 10° above normal from 2nd to 14th inclusive. On 2nd exceptionally high temperatures in the West set up new records; Blacksod Point recorded a maximum of 64°, and as far as Cape Wrath there was a reading of 63°. Sunshine figures were unusually high in many places, the record being broken at Ross-on-Wye. Rainfall was most unevenly distributed, falls greatly in excess of the normal occurring in Ireland, Birmingham and Falmouth for example, while at Renfrew, Stornoway and elsewhere the month was abnormally dry.

The month opened with a mild southerly type of weather affecting all areas except Midlands and Eastern England where low temperatures and fog still obtained. By the morning of 2nd the anticyclone over Western Europe had receded and mild weather with moderate southerly winds had spread to the remaining districts. A ridge of high pressure moving eastward was accompanied by dry and cooler weather on 4th, but another deep depression behind it soon brought a resumption of mild and wet weather that continued until 14th. At Castle Archdale in Ireland 65 mm. fell in the 36 hours ending 0900 on 6th. On 15th temperatures began falling slowly as westerly winds of more northerly origin than of late became established; pressure rose steadily and from 16th to 27th dry and colder weather were general with easterly winds.

While Christmas Day was cold, Boxing Day was exceptionally so with screen minima including 15° at Bristol, 19° at Croydon and Manchester, and a maximum of 27° at Birmingham and 30° at Croydon. By 28th unsettled weather was general and gales were reported from most coastal areas during the last three days of the year; 57 mm. of rain fell at Pembroke Dock in 12 hours on 30th and 47 mm. at Birmingham, while on the night of 30th-31st, snow lay 6-7 in. deep in parts of Yorkshire Moors and 7½ in. deep on the low hills near Mansfield, Notts. Those who read Dr. C. E P. Brooks's article in *Weather*, Vol. I. pp. 107 and 130 will recognize this as being one of the most marked of the " Annual recurrences " to which he draws attention.

	TEMPERATURE (°F.)				RAIN (mm.)*			SUNSHINE (hr.)		
	Long period Average		This month Extreme		Month	Diff. from Av.	Last 12 months	Month	Diff. from Av.	Last 12 months
	Max.	Min.	Max.	Min.						
Kew Obsy.	44·8	38·0	57	23	59	— 7	554	44	+ 7	1532
Gorleston	44·1	37·6	56	27	33	—29	545	58	+17	1682
Birmingham	42·6	36·3	57	23	127	+59	854	51	+16	1366
Falmouth	48·8	41·6	†56	†38	191	+32	1079	65	+12	1669
Valentia	49·1	43·0	60	33	252	+89	1464	39	0	1258
Aldergrove	43·9	36·7	58	25	117	+24	902	46	+ 5	1306
Holyhead	46·9	42·5	56	27	103	— 3	856	68	+27	1549
Tynemouth	44·4	38·4	57	27	44	—11	688			
Renfrew	43·6	35·8	58	25	43	—70	1222	25	— 2	1206
Aberdeen	42·6	34·8	54	22	92	+ 6	833	63	+19	1429
Stornoway	44·9	38·5	58	26	86	—61	1178	24	+ 2	1238

* 25 mm. = 1 inch (approx.) † The Lizard C.R.B.

LETTERS TO THE EDITORS

Low Cirrus

Occasionally an observation has been made of cirrus moving below a layer of middle cloud or even of low cloud For instance, Capt. C. J. P. Cave described in *Nature* an observation of cirrus below altocumulus on January 24, 1926, and a similar observation at Leuchars on March 11, 1938, is described by D. W. Cruickshank in the *Meteorological Magazine* for November 1938.

I saw something similar from Wrexham on June 20, 1948. On that day a ridge of high pressure was moving eastwards and upper winds were backing in advance of an occlusion approaching from the west. Cumulus clouds were stratifying in the morning and moving from WSW. and a halo was frequently visible, originating in almost invisible cirro-nebula. The base of the low cloud could not have been higher than 5,000 ft. At 12.20 a large number of fairly dense cirrus threads approached from the NWW., the same direction as the ground wind, and at a speed far greater than that of the cumulus. There is no doubt that they passed below the cumulus, and a halo was seen as they passed the sun. Now with a surface temperature of 61 degrees it is impossible that ice-crystal clouds could exist below 5,000 ft., so the halo must have been formed in a much higher invisible layer.

Nevertheless, the question of the cirriform cloud at low levels remains. True cirrus can exist at lower levels than was at one time supposed ; anvil cirrus, possibly detached from the cumulus giving rise to it, can also exist in the alto-level. But it seems probable that clouds of similar form, consisting of necessity of water drops, can exist very low down in the troposphere. It would be interesting to hear if any pilots have encountered such clouds, or if anyone has observed a corona formed in them.

Wrexham S. E. ASHMORE

A Ghost is laid to rest?

In *Weather*, April 1947, page 104, it was interesting to read : " It is high time that the ghost of the famous Blackadder (Berwickshire) thermometer reading $-23°$ F., credited to December 4, 1879, was laid for good ". The reason given for this statement was that the thermometer, exposed only two feet above the ground on an open site facing north and protected from the rain by a sloping board measuring a few inches across, was subject to radiation from the ground at least; consequently the Blackadder temperatures, representative of non-standard conditions, were rightly rejected by the Meteorological Office.

The reading of $-16°$ F., registered on the same night in the Kelso district close by, was taken as the correct interpretation. The record of $-17°$ F., 16 years later (1895) at Braemar, elevation 1,100 feet, as contrasted with Kelso, elevation 100 feet, has been accepted as the lowest reading ever recorded throughout the United Kingdom.

But has the ghost been really and truly laid ? In the very same issue (page 127), no less an authority than Mr. L. C. W. Bonacina refers to the Blackadder minimum to illustrate an interesting point I would respectfully submit that, perhaps, the ghost has not been laid for good, and give the following reasons for saying so :

It has been agreed that the thermometer at Blackadder was a reliable one In altitude it is slightly higher than Kelso (Roxburghshire) and lies north-east (20 miles approx) Referring to a good Ordnance survey, what does one find ? Is it not the case that Blackadder rests on a site from which cold air cannot easily find an escape, whereas Kelso lies in the valley of the Tweed in more open country where pools of cold night air cannot so easily form ? Consequently, would it not have been just that little extra colder on the night of the 4th at Blackadder to produce that " record " low which may only have lasted a few minutes ?

A correction is certainly necessary to the reading of $-23°$ F. because of the exposure of the thermometer at only two feet above the ground, but had a minimum thermometer exposed in a regulation screen been placed beside the " erring " thermometer, would it be necessary to allow 7° F. as representative of the conditions at the time ? Would not 4° F have been nearer the mark ? It seems a pity that the famous Blackadder reading should be expunged from the records for all time, and I respectfully submit that a corrected reading of $-19°$ F. should have been allowed to stand as a true picture of the remarkable conditions ruling at that time.

Melrose, Roxburghshire G. BAIN ROSS

A Sudden Squall

I thought you might be interested in an account of conditions yesterday, July 4, when there was a squall described by local yachtsmen as " the worst for thirty years "

During the day the wind turned from S. to W. with alternating periods of calm and light breezes, accompanied by heavy showers from thick cloud which broke only occasionally. I estimate the temperature at 50–55 degrees.

At 4.10 p.m. B.S.T. there were two peals of thunder to the westward; shortly afterwards the wind fell to flat calm at ground level with the general cloud mass moving slowly from the west. At 4.49 p.m. cloud speed increased abruptly to about 25 m.p.h., with a low layer of light cloud travelling rapidly across the mass from the NW. Ground conditions remained calm for two minutes before the squall struck with violence sufficient to rip leaves and twigs from the trees. It must have been a wind speed of at least 30 m.p.h., accompanied by torrential rain. This lasted for about six minutes before the main force passed, to be renewed at intervals with rather less violence. Wind speeds remained relatively high for the rest of the evening and the temperature fell considerably by 6 p.m. In the absence of a thermometer I am unable to give precise temperature data.

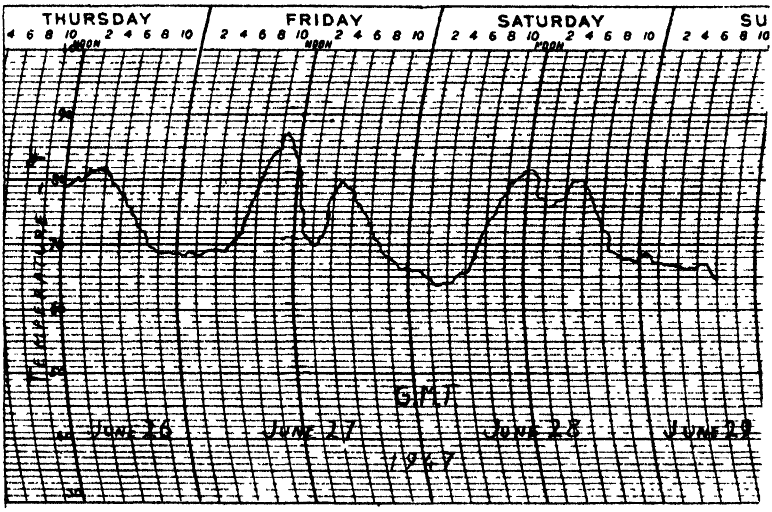
The interesting feature of the squall was the action of wind on the clouds at 4 50–4.56 p.m. The light cloud travelling from the NW. across the mass moving from the westward could be seen striking a westerly current and describing a 45′ arc, which gave the effect of a whirlwind in the clouds. By the time the squall was over wind direction was N. and remained so for the remainder of the evening.

Sunderland, Co. Durham — Miss J Whillis

Temperature variations in a storm

As suggested in the letter from Mr. S. R. Giddings in your June issue, I have looked up my thermograph record for the period June 27–29, 1947. The instrument is rather an old one and has some lag, but is exposed in a Stevenson screen.

The trace shows considerable temperature changes on the afternoon of June 27 when thunder and showers occurred here with wind from SSW. veering to W. Earlier, at 02.30 G.M.T. on the same day, there was little temperature change with a thunderstorm and heavy rain, but the even temperature in the early hours was distinct from the usual steady drop and quick rise about dawn. Temperature changes with a thunderstorm and showers are also shown on the afternoon of June 28.



The minor peak in the temperature record in the early hours of June 29 when we had a severe thunderstorm and heavy rain, would appear to confirm the structure for that storm suggested by Mr. K. F. Phelps in his letter in your February 1948 issue.

Ipswich, Suffolk — J. Stoton

INSTRUMENTS, BOOKS, Etc., WANTED or FOR SALE

For Sale

"Weather," June 1946—June 1948, inclusive. Offers :—Saunders, "Nutwell." Grange Road, Broadstairs.

FEBRUARY 1949

WEATHER

Vol. IV No. 2

CONTENTS

EDITORIAL

Industrial Meteorology is a branch of meteorology which has received little explicit recognition in this country. It is true that the Society held in 1943 a discussion on " The Applications of Meteorology to Industry " and, in 1945, a joint discussion with the Institution of Electrical Engineers on " Weather and Electric Power Systems ", but nevertheless industrial or applied meteorology has not yet achieved a real status as a profession or even as a self-contained branch of the subject.

This situation is all the more remarkable when one considers the manifold applications of meteorology in many industries. For example, the demands on the electricity and gas industries are affected to an important extent by air temperature, wind and fog, while the transport of coal to generating stations may be seriously hampered by weather as in the winter of 1946-47. The output of hydro-electric stations is entirely dependent on rainfall, and a knowledge (and if possible a foreknowledge !) of the amount and the seasonal variation of rainfall is of prime importance. Again, the choice of sites for wind-driven generators should be based on meteorological statistics. Heating and ventilating engineering is, or should be, largely applied meteorology—the problem being to create artificially in a building a comfortable climate irrespective of the weather conditions outside.

In spite of the importance of weather in many industrial processes, the technicians concerned frequently do not even know how to obtain the information they require and which is often readily available. There would seem to be considerable scope in industry for technical staff with a knowledge both of meteorology and of the special requirements of the industrial processes in question. Finally, let us hope that the distinction which Professor Brunt humourously made at a meeting of the Society between the " Industrial " meteorologist and the " industrious " meteorologist is not altogether justified !

AIRMET AND ITS USES

By Lieut. Cdr. P. C. Spink, R.N.V.R.

Apart from the obvious uses of the Airmet Service for glider pilots and owners of private aircraft, there are many other functions to which it can contribute if used appropriately. Foremost, in my opinion, is the very excellent practice it affords the amateur meteorologist of " keeping his hand in ". In other words, the war-time forecaster, who both enjoys and is interested in the vagaries of British weather, is enabled to draw a daily chart, very rough it is true, with only low cloud amounts, present weather and pressure to plot on a skeleton network of stations covering the British Isles and but a fraction of North-West Europe. This is enough, however, to obtain some idea of the synoptic situation as affecting the British Isles, from hour to hour if necessary, and if the recipient is fortunate enough to live in either eastern England or Scotland, he is enabled usually to make a fairly reliable 24-hour forecast.

I use two frames of perspex covering a meteorological chart of the area concerned. I find that perspex is a better material than glass, though the latter will serve. With the usual coloured chinagraph pencils and a bottle of methylated spirits for erasing, very tolerable maps can be drawn. In addition, I use a tephigram fixed between two perspex sheets for plotting the upper air soundings. Besides providing a means of gauging the humidities at various heights, isothermal layers and inversions, the latter is useful for determining the stability or instability of the air masses over the British Isles, and has proved useful in thunderstorm forecasting. In addition, by gauging the depth of cold or warm air, the tephigram is most helpful in deciding how long a spell of frost or drought is likely to last, or whether the upper air is becoming colder or warmer. During the 1947 winter I found the upper air information most helpful in forecasting local conditions, and again during the drought of August 1947.

I have made considerable use of Airmet for industrial purposes ; in the type of business I am engaged in it is important to know whether there will be night frosts, whether a sudden warm spell is likely to occur (such as the advection of tropical maritime air on November 20, 1947), and the type of air mass and humidity expected during the next 24 hours. For the transport side of the business, radiation-fog forecasts are important ; also, for example, what the road conditions are like across the Pennines for heavy lorries during a wintry spell, or whether a lorry with a perishable load would get through to Glasgow or London in quick time. These are all important problems which can be answered with a fair degree of confidence by the correct use of Airmet, together with some fundamental meteorological knowledge.

In a comparatively short time I trained a youth of eighteen, with a scientific training, in the fundamentals of meteorology, and after a few weeks he became quite competent to draw Airmet charts and make local forecasts in my absence. Indeed, I enthused him with the subject, and with no persuasion he reads meteorological literature (including *Weather*) in his spare time !

Apart from the utility application of Airmet to industry, there is the sheer interest and entertainment value of watching weather develop from hour to hour. At a week-end, with a falling barometer and wind backing south, it is interesting to draw a chart and find the exact location of the approaching front, and by roughly gauging the surface wind speeds from the isobars, to time the arrival and calculate the extent of the rain belt. If a particularly interesting sky is noticed one can obtain the synoptic situation which has caused it. During February 1947 it was easy to forecast the successive snowstorms by watching the development and advance of depressions to the south of the dominating

anticyclone. Knowing the depth of the cold air mass as revealed by the morning upper air sounding, it was not difficult to forecast snow from the south-east under such conditions. For assessing the day's weather in general, nothing could be better than the drawing of an early chart. From it can be decided the day's programme out of doors, whether gardening, farming, a picnic, climbing a mountain, a day at the seaside or any other activity conditional upon the weather during the next few hours. A broadcast meteorological forecast is useful, but how much more satisfactory and reassuring it is to have the visual evidence in the shape of a weather map, showing how the situation has developed within the past hour.

During the early days of August 1947, while on holiday in the Lake District, it was gratifying to watch the development of the anticyclonic conditions which subsequently were to dominate the month. In spite of various mornings with a low cloud cover of stratocumulus, one could embark on mountain trips with every confidence of fine weather.

Whilst on a trawling trip in the North Sea last summer I found it was easy to draw charts, and it occurred to me at the time what a useful service Airmet could render to a trawler or drifter, particularly in winter, as far as gales or sea fogs are concerned. Racing yachtsmen should appreciate the service too, since a very good assessment of wind force and direction can be made provided the sea-breeze component is taken into account during hot weather. The cruising yachtsman is enabled to spot depressions and the onset of strong winds, and with the synoptic picture in his mind has no need to run into trouble.

The hourly broadcast is really excellent and the commentary by the forecaster is extremely informative and helpful. If criticism is permissible, I should like to suggest that the forecaster is a little more " chatty " and refers to the previous day's weather more often in order to link up the unending serial of the weather story. This is done by one forecaster in particular ; his commentaries are a joy to listen to. More explicit demarcation of fronts and their type would be helpful, instead of so often referring to them merely as frontal troughs, with only vague positions given. Regarding the actual station reports, the force and direction of wind would be useful, though it is realized that here the time factor has to be taken into account when giving these reports. The inclusion of Atlantic weather-ship reports also would be extremely useful, since they would provide some indication of conditions to the west of the British Isles.

TO A LOST AIRMET VOICE

O golden voice whose lilting tones for long
Made Airmet broadcasts like a soothing song,
Voice that one sultry evening last July
Didst harrow us with Niobean sigh
While putting out the duty prophet's warning
Of thunderstorms and heavy rain ere morning ;
Voice that, when words went wrong, camest nigh to tears
In limpid murmer of " Oh dear, oh dear's,"
Where art thou now ?

Did talent-spotters from the B.B.C.
Tempt thee with offer of a lordly fee
To quit the halls of Dunstable and fare
Southward to captivate the London air ?
Did crooning call thee ? Hast become a wife,
The joy and pride of some announcer's life ?
O voice, remembered voice, where art thou now ?

F.R.MET.S.

STANDING WAVE EXPLORATION BY SAILPLANE

By A. H. Yates, B.Sc.

A sailplane, having a minimum rate of sink of only two or three feet per second, is an excellent instrument for the investigation of vertical currents in the atmosphere, since in any upcurrent of over three feet per second the sailplane will climb and the variometer will indicate this rate of climb. For many years glider pilots have used the upward component of the wind velocity over such escarpments as Dunstable Downs and The Long Mynd in Shropshire and more experienced pilots are able to climb in the " thermals " under cumulus clouds. A third source of rising air is now interesting glider pilots—that due to waves in the atmosphere which are fixed relative to the ground—the " standing waves " as they are called. A series of standing waves may be produced when the wind is deflected upwards by a mountain ridge but a necessary condition appears to be the presence of a temperature inversion in the atmosphere or at least a stable lapse rate.

A FLIGHT IN A WAVE

On Sunday, September 19, 1948, I visited the Midland Gliding Club site at The Long Mynd for a morning's soaring before de-rigging my *Olympia* sailplane and towing it in its trailer back to Cranfield. The wind was westerly and blowing on to the escarpment so I obtained a launch at 09.15 (B.S.T.) although I had not yet breakfasted. We had listened to the Airmet information for glider pilots at 08.25 and had plotted the tephigram. There was a marked inversion at about 4,000 ft. above sea level and cloudy weather was expected in the west. At the time of take-off the cloud consisted of 8-9/10 strato-cumulus with base about 1,000 ft. above the Long Mynd (i.e. 2,500 ft. above sea level).

For 50 minutes, accompanied by another "Olympia", I "slope soared" along the ridge at 500-600 ft. above it (A in Fig. 1). Just when I was thinking of breakfast, I found a patch of cloud under which there was gentle lift. I circled in it and entered the rather dirty-looking mass at 1,000 ft. I continued circling for some time (B) until I noticed the cloud getting lighter, showing that I was nearing the top, but the lift remained smooth at 3-5 ft. per second. An almost overcast sky at 09.00 is not normally expected to give much lift and the smoothness of the air made me suspect a standing wave.

I therefore stopped circling and flew upwind—by compass—until I emerged from the top of the cloud at 2,300 ft. and continued a steady climb of 2-3 feet per second into the blue. There were no high clouds except a trace of cirrus away to the north. The sunshine reflected on the layer of cloud beneath was almost blinding and in my perspex covered cockpit I was soon comfortably warm. There was a fine display of " glory ", sometimes called " spectre of the brocken ", as I flew along over the cloud sheet. The bright circle of reflected light tinged with rainbow colours was spanned by the long shadow of the sailplane's wings.

I did not notice any change in atmospheric temperature but another pilot,

who also climbed through the cloud in a glider with an open cockpit, reported a marked warming of the air as he climbed, thus confirming the inversion reported from the early morning ascent. The absolute smoothness of the air in a wave is in contrast to the turbulent lift encountered under and inside cumulus clouds and to the less turbulent lift along a slope. The only sound was the hiss of the air over the surfaces of the sailplane and I amused myself by trying to detect the stall by ear as I reduced speed. In the smooth air the first indication of the air flow separating from the wings was heard as a slight change in the hiss.

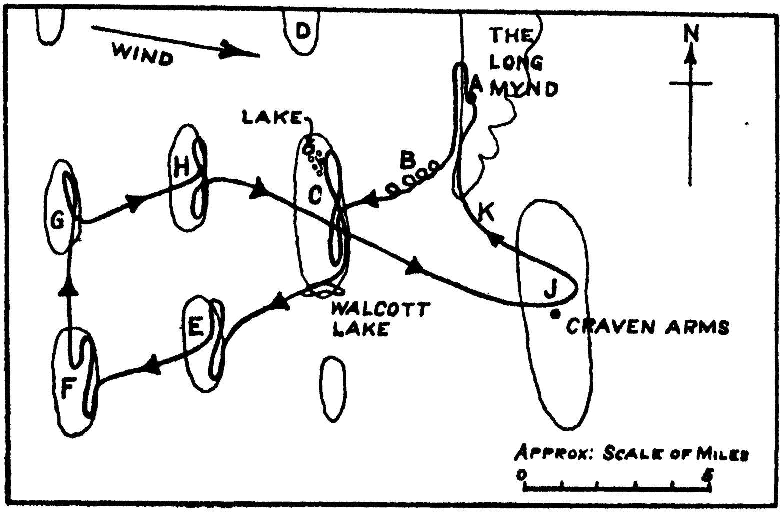


Fig. 1. Plan of the Flight.

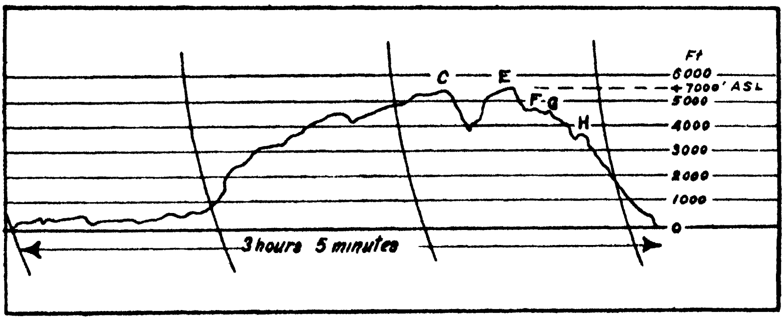


Fig. 2. Barogram of the Flight.

All this time the *Olympia* was climbing steadily toward the west and I found in front of me a long trough in the upper surface of the cloud. I could now see that the upper surface of the cloud consisted of shallow waves with crests and troughs running across wind—that is from north to south. I had emerged on the upwind side of a crest and the trough in front of me contained a large hole (C) about one mile wide and stretching about three miles from Walcott Park Lake in the south to another smaller lake in the north. There

was another hole in the same trough further away to the north (D). I turned and flew up and down along the downwind edge of the hole for some time and, after some exploration, discovered that the lift was best along this edge and gradually diminished in the other directions. After climbing for over an hour I reached 5,500 ft. above the launch. I could see that the top of the whole layer of cloud was corrugated in these shallow waves running across wind. The troughs did not continue indefinitely : several gradually filled up and faded out while others started alongside. Occasionally the trough deepened and the cloud vanished leaving an elliptical hole like the one over which I was now flying. It was easy to see that these rollers were stationary with respect to the ground—my beat remained between the two lakes for more than half an hour although at that height the wind was about 35 m.p.h. It was odd to see a few farms continuously bathed in sunshine while almost the whole of the countryside was in shadow.

I then decided to explore one or two of the holes which I could see in the bottom of other parallel troughs. In order to reach the next one upwind I increased speed from my usual 40 m.p.h. to 80 m.p.h. and made headway against the wind and through the down-draught on the upwind side of the hole and over the next crest. I lost 1,600 ft. in the process but, as I expected, found lift again along the downwind edge of this hole (E). I soon climbed back to 5,600 ft. (7,100 ft. above sea level) and again set off upwind to the next trough. I explored two holes in this trough (F,G) and in each found the usual 3-4 feet per second upcurrent on the downwind edge of the hole.

As I could see only a few fields through each hole I had no idea how far upwind I had gone so I decided to return to my original hole in order to descend through it to the Mynd. I checked the lift in another hole (H) en route and on reaching my first trough found the holes had all filled up (during the whole flight in fact, the holes were tending to fill, due, as I afterwards realised, to a falling cloudbase). I was not even sure by now which was "my" trough. There was, however, still a large hole in the next trough downwind so I flew over to it (flying downwind is a speedy procedure) and with great good fortune saw a small town and railway junction which could only be Craven Arms (I hoped). Discretion urged me to descend through this hole and land in one of the fields I could see below but the complications of fetching my trailer made me decide to try to regain the Mynd. I therefore set compass course to the north-west and plunged into the clouds again. With luck I broke cloud 800 ft. above the Mynd at the south end and was able to land back at my take-off point.

THE PHYSICS OF STANDING WAVES

It is well-known that a stone on the bottom of a stream can cause a series of waves in the water surface downstream from the stone. Similarly a ridge on the stream bed approximately across the stream will cause a series of waves downstream with their troughs and crests parallel to the ridge. The water surface is, of course, merely the surface of separation of two fluids of different densities, and it has been demonstrated that similar waves can be produced at

the surface between other fluids of differing densities. A close approximation to such a surface occurs in the atmosphere at a sharp inversion. Here, at about the same pressure, we have layers of air at different temperatures and, therefore at different densities ; the warmer, less dense, air being on the top. If the wind now blows over a mountain ridge lying approximately across wind, the air will be deflected up over the ridge and a series of waves will be formed downwind (Figure 3). A mathematical investigation into the factors affecting the amplitude and length of these waves has shown that a discontinuity in density is not necessary but that a normal inversion, or even merely a stable lapse rate, will allow waves to form. Another factor greatly influencing the amplitude and length of the waves is shown to be the wind gradient at the height concerned. If there is no cloud near the inversion level the waves will not be visible but they have several times been used by sailplanes. A German glider climbed to 37,000 ft. in a wave in the lee of the Alps in 1940. The

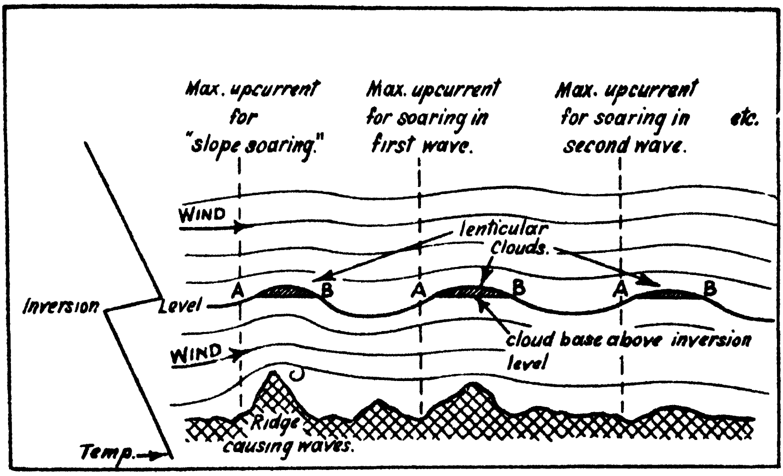


Fig. 3. Standing Waves and Lenticular Clouds.

maximum upcurrent will occur upwind of the crest (A in Figure 3) and the maximum downcurrent behind the crest (B in Figure 3). Over the crest or over the trough the pilot would expect to find neither. This transition from up to down should be very gradual and the strength of the up or down currents vary gradually from a maximum at the inversion level to zero at the ground and at a great height above the inversion. These expectations are borne out by the sailplane flights in these waves.

If the humidity is about 100% near the inversion level the waves may become visible. If the condensation level is just above the inversion level no cloud will form unless the waves carry some of the cold air above both levels when the further cooling of the cold air due to the expansion will cause condensation. Clouds may then form on the wave crests (Figure 3) and are known as lenticular clouds. They have the peculiarity of remaining stationary with respect to the ground ; the cloud is in fact constantly evaporating at the rear

while fresh cloud is forming at the front. The presence of such clouds is a certain indication to the sailplane pilot of the presence of standing waves. He is still faced with the problem of getting his sailplane somewhere underneath the point A and high enough to find an upcurrent greater than the sinking speed of his sailplane, and he must depend for this either on slope-soaring over some convenient hill or on thermal currents which may be present under the inversion.

If, however, the condensation level is below the inversion level the cloud cover becomes much more nearly complete (Figure 4), as it was during the flight I have described. The layer of the cold air between the inversion and the condensation level will now be saturated. The existence of waves in the inversion level may, however, still be noticeable from below since the thickness of the cloud layer will vary from a maximum at the wave crests to a minimum at the troughs. From below the cloud will appear to have light and dark

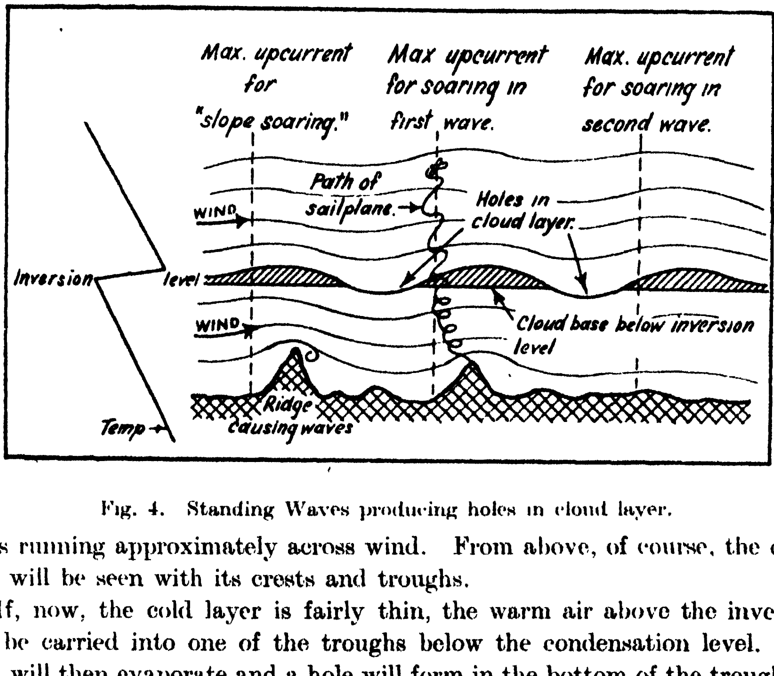
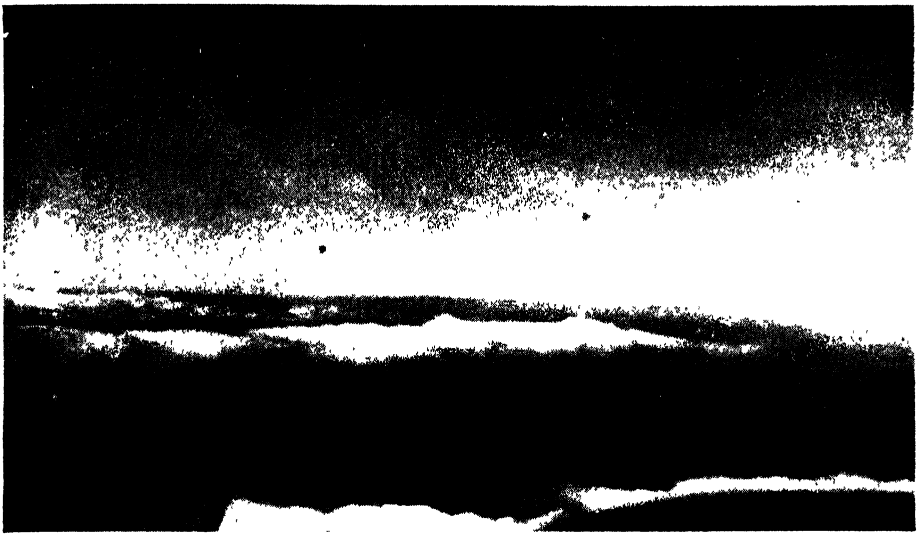


Fig. 4. Standing Waves producing holes in cloud layer.

ridges running approximately across wind. From above, of course, the cloud sheet will be seen with its crests and troughs.

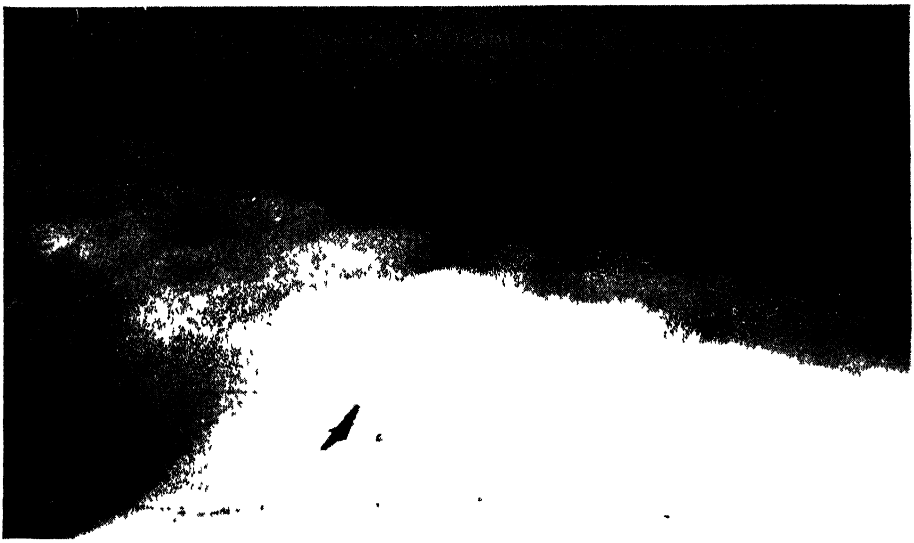
If, now, the cold layer is fairly thin, the warm air above the inversion may be carried into one of the troughs below the condensation level. The cloud will then evaporate and a hole will form in the bottom of the trough. If the waves were caused by a single, very long mountain of uniform height, the hole would appear as a long slit in the cloud but, since the waves are usually produced by uneven mountain ridges, the trough depth varies along its length. The holes are, therefore, irregular in outline and approximately elliptical.

Again, the sailplane pilot will find the greatest upcurrents near the leeward edge of the hole or trough. The lift extends well above the cloud tops and provided that the pilot can contact the upcurrent by using slope lift or a "thermal" he can climb through the cloud layer either through the leeward



Photograph taken above Asterton by Carl A Beck at 14.55 G.M.T. on September 17, 1948, in a two-seater sailplane which entered cloud-base at 1,000 feet above launching and emerged at top surface at over 2,000 feet above launching. At the bottom is the cloud over which he was soaring at 3,500 feet above launching.

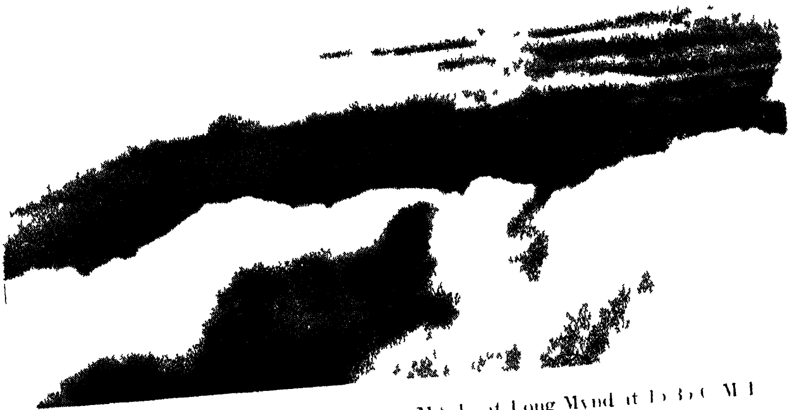
Photograph by] [*C. A. Beck*



An Olympia sailplane climbing in the up-current above the windward part of the wave cloud at 15.05 G.M.T., September 17, 1948. In the distance are the remnants of the next wave down-wind, east of the Church Stretton Valley.

Photograph by] [*C. A. Beck*

PLATE 1



Wave clouds seen from 4,000 feet above M.S.L. at Long Mynd at 1535 G.M.T. on September 16, 1948, looking West

Photograph by [*C. J. Wingfield*

Barographs being presented by Sir Nelson Johnson (centre) to Capt. W. G. Higgs (left) and Capt. R. P. Galer in recognition of their voluntary meteorological work at sea

Photograph by] [*The Sta*

PLATE II

part of the hole or through the cloud (as I did). By flying above the leeward edge of the hole the pilot can continue his climb until the upward component of the wind velocity falls to equal his sinking speed. He has then reached his ceiling but, as other waves may produce stronger lift, he may decide to fly either up or downwind to the next wave.

I found, as I expected, the best lift on the leeward edge of each hole. Further along the trough where the clouds closed in again (a sign that up and down wave velocities were weaker) the lift was found to be weaker. The maximum rate of climb found was only five feet per second—i.e., a maximum upcurrent of about eight feet per second. This is weak compared to the 10-20 feet per second often found in cumulus clouds and the much greater values recorded in cumulo-nimbus clouds but absolute smoothness of the lift makes standing wave flying very pleasant.

VOLUNTARY METEOROLOGICAL WORK AT SEA

Meteorologists all over the world are dependent upon the voluntary work of the masters and officers of merchant ships for information concerning the weather over the oceans. Coded weather messages are sent by these merchant ships to appropriate shore stations by radio, and written records are sent in to the Meteorological Office from each ship at the end of her voyage. At the present time, 500 British merchant ships are contributing to this ocean network.

In recognition of this important voluntary work by ships' officers, it was recently agreed that the Meteorological Office should make an award each year of a book of a scientific nature, to the master, senior observing officer and radio officer of those ships whose work during the year had been classified as " Excellent ". A special award should also be made each year to a maximum of four masters or officers who had taken part in this voluntary work over 15 years, and whose work had been particularly outstanding during that period.

This year, the masters of four British merchant ships were selected to receive this special award, which took the form of a barograph in a mahogany case Engraved upon a silver plate read :—" Presented by the Director of the Meteorological Office, London, to Capt . . in recognition of his valuable meteorological work at sea, 19 to 19. ." The recipients of these barographs were Captain J. E Wilson, O.B.E , (1931, 16) " Nova Scotia " (Furness Line), trading between Liverpool and Newfoundland ; Captain W G Higgs, O B.E., (1910, 42) " Port Wellington " (Port Line Ltd), on the New Zealand trade ; Captain R P. Galer, C B E., R.D., R.N.R , (1933, 8) " Clan Macdougal " (Clan Line), engaged on the Far East trade ; Captain W. H Downing, (1921, 13) " Manchester Progress " (Manchester Liners Ltd.), trading between Manchester and Eastern Canadian ports. The date and number after each name refer to the year when the recipient first became a voluntary observer, and the number of occasions when his observations were classified as " Excellent ".

Two of the presentations were made, on separate occasions, by Commander Frankcom, the Marine Superintendent of the Meteorological Office, and two by Sir Nelson Johnson, the Director. The ceremonies were attended by senior officers of the shipping companies and of the Meteorological Office. They were marked by excellent little speeches and a general bonhomie—maybe this was, as a landsman remarked, partly due to the breath of salt in the air. Sir Nelson Johnson reminded those present of Darwin's voyage in the "Beagle", in the command of Fitzroy who subsequently became the first Director of the Meteorological Office. He also referred to the work of Maury. Seamen had thus contributed much to meteorology from very early days, and the work of voluntary observers at sea had continued to add very materially to our knowledge. He complimented Captain Higgs, an observer since 1910, as the doyen of the Voluntary Observing Fleet.

Several speakers pointed out the value of systematic observations both to seamen and owners. The Captains who received the awards stressed the parts played by their junior officers and emphasized the enjoyment they derived from meteorological work at sea.

C.E.N.F.

AN INTERNATIONAL METEOROLOGICAL ROMANCE

On December 18, 1948, the wedding took place in London between Mr. N. vander Elst, Director of the Congo-Belge Meteorological Service, and Miss Patricia Jordan of Lausanne, Switzerland, lately a member of the I.M.O. Secretariat. This meteorological romance blossomed in Washington during the autumn of 1947, amid the toils of the Conference of Directors of the I.M.O. Mr. vander Elst was attending the Conference in his official capacity as delegate, and Miss Jordan was one of the hard-working and very helpful members of the I.M.O. Secretariat. The work of the Conference was very strenuous and it was quite a feat to have found the time for romance, but love overcometh all obstacles, and possibly the Washington atmosphere, at its best in the fall of the year, contributed in no small degree to Cupid's triumph.

Mr. vander Elst is well-known to many in the Meteorological Office for, apart from his international activities, he served as a Flying Officer and later as a Flight Lieutenent in the Meteorological Section of the R.A.F.V.R., from 1942 to 1945 at several stations in the United Kingdom.

We extend our best wishes to Mr. and Mrs. vander Elst for their future happiness.

INSTRUMENTS, BOOKS, ETC., WANTED OR FOR SALE

FOR SALE

ROYAL METEOROLOGICAL SOCIETY NEWS

The third of the series of popular meetings arranged by the Council of the Society was held on January 12 in the lecture theatre of the Science Museum, with Sir Robert Watson-Watt in the chair. In several senses this meeting can be described as an historic occasion as it was devoted to a lecture by Sir George Simpson on " Atmospheric Electricity during the last 50 years." In order to bring such an extensive subject within the confines of a single lecture, Sir George said he would limit his lecture mainly to fine weather electricity and would discuss two classical problems, (a) the origin and maintenance of the earth's charge and (b) the cause of the ionization of the atmosphere.

Nearly 200 years ago (in 1752) Franklin and Dalibard showed that thunderstorms were electrical phenomena, and shortly afterwards it was discovered that an electrical field, corresponding to a negative charge on the earth, was always present, even in fine weather. At that time the earth's charge was thought to be a static charge which had remained on the earth since it was made and the daily variations in the field were ascribed to the movement of charged water vapour in the atmosphere. In 1899 (just 50 years ago) the whole science of atmospheric electricity was profoundly affected by the discovery by Elster and Geitel and by C. T. R. Wilson that the air is not a perfect insulator and that any charged body will lose about 5 per cent. of its charge in one minute. Accordingly, the existing theory of the earth's charge was untenable and some mechanism must be found which would provide for continual replenishment of the charge. Some experiments made by Zeleny indicated that a body in a stream of ionized air would acquire a negative charge. and it was suggested that the earth's charge could be attributed to this effect. Simpson, however, repeated Zeleny's experiments and was able to show that the charge might be either positive or negative and was, in fact, determined by the voltaic difference of potential between the metals of the body and the enclosure. Sir George remarked that, appreciating the significance of his findings, he reported them in a letter to *Nature*, but the Editors replied that they could not publish the letter as the experiments were not conclusive ! It was next postulated that the areas of disturbed weather were somehow responsible for the maintenance of the earth's charge. but in the light of the then available knowledge of the upper atmosphere, little progress was made for about 15 years. In 1920, however, C. T. R. Wilson propounded an ingenious theory showing how the negative charge over the whole surface of the earth could be maintained by thunderstorms in the disturbed areas. This theory, however, depended on the existence of the Heaviside layer—which had not yet been demonstrated experimentally—and on the assumption that in a thundercloud the positive charge is located in the upper parts of the cloud and the negative charge below. The evidence for the theory was strengthened in 1925 when Appleton and Barnett proved the existence of a conducting region in the upper atmosphere, and was further reinforced during 1933-39 when Simpson, Scrase and Robinson were able to show by balloon soundings that the polarity of thunderclouds was in accordance with Wilson's assumption. Another important result based on the work of Hoffmann (1923), Mauchly, Whipple and Scrase, was that the curve of the daily variation of world thunderstorms is similar to that of the variation of potential gradient over the oceans and polar regions. In this connexion Sir George mentioned as an example of the tribulations of research, that although he showed that the potential gradient curves (in local time) at places of different latitude could be superimposed, he failed to notice that a single universal curve was obtained if the results were

plotted in terms of Greenwich time.

Discussing the cause of the ionization of the atmosphere, Sir George said that he had made a year's observations at Karasjok, 150 miles within the Arctic circle, and had shown that daylight, auroral activity and other meteorological factors had little effect on the intensity of the ionization. Radio-activity in the earth's crust was an important cause of ionization, but the intensity did not decrease with height in the way which would be expected if this were the sole cause. In fact, Hess and Kolhörster, in 1911-1913 found that after the first kilometre, the intensity of ionization increased with height to 80 ion pairs per cm ^{3} per sec at 10 km compared to about 3 at ground level From the law of increase in intensity with height it was possible to deduce that a highly-penetrating radiation was entering the earth's atmosphere, and the new subject of cosmic rays was born In concluding his lecture Sir George, said that the meteorologists might take credit for having introduced cosmic rays to the physicists.

Sir Robert Watson-Watt, in proposing a vote of thanks to the lecturer, said that the history of atmospheric electricity was an excellent example of the scientific method—formulating an hypothesis to fit the known facts and discarding it when it had outlived its usefulness. He added that Sir George had done his best to conceal the fact that the history of atmospheric electricity during the last 50 years and the history of Sir George Simpson were essentially the same !

Annual General Meeting

The Annual General Meeting of the Society was held on January 26, 1949, when the Report of the Council for 1948 was adopted. Owing to a comparatively large number of resignations, and names that had to be crossed off the list of membership in accordance with the By-laws because their subscriptions were two years overdue, the total membership is somewhat less than it was a year ago ; the large majority of resignations were, however, those of Fellows who joined the Society during the war years The President told the audience that Mrs. Hayman, the Assistant Secretary since 1944, had resigned in order to allow herself more time for study with the object of becoming a concert pianist ; he thanked Mrs Hayman for all she had done for the Society during some difficult years, and presented her, on behalf of Councillors past and present, with Grove's *Dictionary of Music and Musicians* in six volumes He expressed his concern over the season's financial position of the Society, due partly to the increased cost of living and to higher printing costs, and also to the large number of Fellows whose subscriptions were in arrears

The Symons Medal, awarded biennially for distinguished work in connection with meteorology, was presented by the President, Dr. G M B Dobson, F R S to the Swedish Chargé d'Affaires, Monsieur Östen Lundborg, on behalf of Professor Tor Bergeron.

Dr. Dobson also announced the annual awards of the Darton Prize for 1948 to Mr F H. Ludlam and Mr. C. A Wood This is reported upon in more detail on p 53

The Presidential Address on "Ice in the Atmosphere" was then delivered by Dr Dobson ; this will be reported in some detail in the March number *Weather*

The work of the Society during 1949 will be carried on by the following new Council elected at this Meeting :—

FORTHCOMING MEETINGS

On February 16, at 5 p.m. in the Society's rooms there will be a discussion on "Large-scale vertical motion in the atmosphere" when recent papers by J. K. Bannon, B.A., and R. C. Graham will be referred to (see *Quart. J. R. Met. Soc.*, Vol. 74, p. 57 and Vol. 73, p. 407). Mr. Bannon will open the discussion.

On March 3, at 6 p.m. in the Lecture Theatre of the Science Museum, Exhibition Road, South Kensington, Professor Gordon Manley will give the next of the series of popular lectures—"British climatic fluctuations since Queen Elizabeth's day"; Mr. Ian Kirkpatrick will be in the Chair. Non-members are cordially invited.

LETTERS TO THE EDITORS

"The Times" Weather Charts

I agree with everything Mr. J. S. Dines says about *The Times* Weather Charts in the September number of *Weather*. In addition I would say that, having only the prebaratic, one has no facts about what is happening, and when the prebaratic goes wrong, as it sometimes seems to do, one is left more bewildered then ever. It is all "in the air" in a most unsatisfactory sense.

New Southgate, London, N.11 J. FAIRGRIEVE

I should like to say that I agree heartily with Mr. Dines' letter in your September number of *Weather* on the prebaratic chart in *The Times*.

I have felt that a factual chart, even though so many hours out of date, would be far more helpful to the average reader who has a sensitive appreciation of his own local weather conditions than the most elaborate prebaratic chart that can be evolved! I have also wondered if it were not possible to print the factual chart for 18 hours of a far greater area than the present one, to give a more general picture of all the possibilities. After all, the *forecast* is given, to help the reader who is not interested in the chart, and to give the local forecaster his lead when forming his own opinion.

Bassett, Southampton GLADWYS M. HAWKESLEY

May I, as an amateur meteorologist, express agreement with Mr. Dines' letter on this subject? Probably most people interested in the movements of anticyclones and depressions would prefer the former *Times* weather map, showing the actual position the evening before. No doubt the weather to come is of more practical importance, but detailed forecasts are given about that. These forecasts are usually substantially right (a fact not always recognized by critics of relatively infrequent bad forecasts). But is there not something unreal about a chart claiming to show the precise pressure distribution twelve hours or more after it is made up?

Bishopsteignton, Devon G. WESTON

Owing to my omission to notify *Weather* of the date of my return from South Africa, the September and October numbers have only recently reached me via S. Africa: and I had not before seen the letters from J. S. Dines and G. Weston about the weather maps in *The Times*. There are one or two points relevant to their criticism which appear to me worthy of mention in justice to those concerned, viz., the Meteorological Office and *The Times*.

The Meteorological Office provides the press with a chart containing *two* maps, viz., a map of the actual conditions at midday "yesterday" and a map of the forecast conditions at midday "today". It would be undoubtedly better if both could be published. If enough readers of *The Times* shared that view, no doubt it would be done. But if a choice has to be made, there are reasons in support of *The Times* decision.

Many people are interested to see what the temperatures and wind *were* yesterday, especially when it has been exceptionally warm or cold or stormy. But the interest is of the type often described as curiosity, legitimate and natural, though not usually having a direct practical application. On the other hand many people, who receive their *Times* early, have a more definite practical interest in the expected temperature, wind and weather of "today" e.g., shall they take umbrella or overcoat, go to the park or the pictures, have their party indoors or outside, stoke or bank their fires.

Naturally the broadcast forecasts are more "up-to-date" but they do not provide the same local and temporal detail as the map: and it is easy to get confused about a broadcast forecast which is only *heard*; the ordinary listener often misses the import of the carefully chosen words of the forecaster because he cannot refer back to them: a printed map can be looked at a second time.

No doubt the amateur meteorologist can often make a reasonably good forecast of "today's" temperature, wind and weather for his own region with the assistance of "yesterday's" map and the professional forecaster's inference. But it has often been represented to me that the layman likes to have the professional meteorologist's definite opinion; he does not want to have to make his own deductions. The map does enable him to get a definite statement of the weather to be expected in the middle of the day, the most important period of the 24 hours to the majority of people. In some meteorological situations, this compulsion on the expert to give a single valued temperature, wind and weather is certainly hard but the frequency of such situations diminishes as science progresses.

A further point is that some readers, both laymen and meteorologists, find pleasure in verifying that the forecast map was right and others, as Mr. Weston implies, get their pleasure, less frequently, by verifying that it was wrong and all these are denied their pleasure if they have only the stark naked facts of yesterday. With both maps their pleasure could be more than doubled.

London, N.W.11. E. GOLD

Changes in the Climate of London: A further note

Your correspondents have raised several interesting points referring to Mr. Hawke's welcome articles. Mr. Hemmings' comment on the effective draughtiness of many earlier 18th century houses is I think, justified by temperature records. Jurin in 1723 recommended that thermometers should be exposed in shady fireless rooms, a practice which, in conjunction with the calendar problem, presents endless headaches to those who would extend our temperature reductions back into the fascinating 1740's. The fashion declined

after 1755, but was still common in Gilbert White's day; for example, Vernon of Middlewich, in Cheshire, observed 21° in "a fireless study facing NE." in February 1772. But Jurin himself, in the middle of London, recorded 26° on his staircase indoors during the penetrating easterly gale of December 29–31 (O.S.), 1739. In his study, with a fire burning, the mid-morning reading was 34°. In an upstairs room with no fire, two windows overlooking the Thames, and no fire in adjacent rooms, a thermometer is said to have recorded "below 11°" at 1 p.m., the spirit being within the bulb. Barker at Lyndon also observed 26° indoors; Short, on his staircase at Sheffield, 28°, and nearby, "in a nobleman's library", 29°. A comparison between some of Barker's later "indoor" and "outdoor" readings certainly suggests that the outdoor temperature in the wind in the Midlands was far below 20° and possibly as low as 15°; he also recorded that ice 3 in. thick formed within 24 hours. Huxham at Plymouth recorded 23° on "the coldest day in the memory of man" with a high north-easter blowing. Dr Labrijn of Holland has kindly confirmed that in Holland on December 30–31 an easterly gale blew with an average temperature of 3° F. Seven observations for each day are available, the range being from +7 to −2 over 48 hours. With a deep current a temperature below 15° in the wind in London seems quite likely.

Later in the month temperature certainly fell below zero at Stoke Newington, "large trees were split" in Enfield Chase, ice was reported to be 10½ in. thick in St. James's Park, 18 in. in the Midlands, 22 in. at Carlisle, 26 in. at Leyden. Numerous contemporary accounts testify to the appalling outburst of continental-Arctic air with which this spell began. It was marked by exceedingly heavy rains throughout south-west Europe and an ice-storm in N. France, recalling the events of March 1947. With customary outspokenness the doctors of a robust age recorded that ultimate test of an 18th century winter, appropriately expressed with more delicacy by Gilbert White (Jan. 27–31, 1776). "during these four nights the cold was so penetrating that it occasioned ice in warm chambers and under beds." But in such respects history was again made in February 1947 in a chilly 17th century cottage near Cambridge, as an ex-naval-officer student was delighted to proclaim.

In order to determine log coefficients with which to treat these early instrumental records I have kept notes for some months in a standard small modern house in an exposed position. In an exceptionally cold fireless upstairs room facing north, with an open wall ventilator beneath which the water-pipes were tidily laid, the extremes during 1947 were 85° and 23°; in the hall, 83° and 34°, outside, 93° and 1°. Housebuilding technique certainly appears to have improved a good deal after 1750, we might presume, from the agreeable comfort of Harley Street and the size of fire-grates; but we still appear to eschew perfection even though nightcaps and four-posters can now be dispensed with.

I cordially support Mr Crossley's comment on the acute danger of generalisations based on statistics of the frequency of hail. The slightest acquaintance with the published data and the astonishing differences even between neighbouring stations of the same class, such as York and Wakefield reveal that no statistics appear to be more dependent on the alertness and constancy with which observation can practicably be maintained. But Kew Observatory is a first-class station at which we may presume an adequate watch; hence the observed frequency of hail (and, incidentally, snow) is understandably far above that at neighbouring stations such as Wisley. Inasmuch as the recorded frequency by a single observer would if anything err on the low side, I think we must accept Mr. Hawke's contention that, compared against the present-day average frequency of "days with hail" at Kew, Gadbury's figures over 20 years are indicative of some difference; though I should not like to say how great, in the light of the wide range of variation shown from year to year even by our major observatories.

My own inclination would be to suppose that maritime-polar air tended to be a shade cooler during the late 17th century, but the matter needs further scrutiny. My surmise is largely based on Thorarinsson's curve of glacier behaviour in Iceland which over the past two centuries bears an interesting relation to the trend of spring temperatures in England; and the glaciers were advancing after 1680 until about 1715. Just possibly this is also related to the greater frequency of night frost reports in summer. I doubt, however, whether these can be accepted entirely at their face value; for one can find upland countryfolk in the north of England who are still disposed to describe almost any clear quiet radiation night in summer as "frosty", although in normal locations the screen minimum does not fall below 40° or so. For example, in 1941 I was told that "frosty nights went on until nearly the middle of August." But I accept the likelihood of occasional air temperatures near or at the freezing-point in summer under the more exposed conditions of former days. How rough was the grass in the newly-formed Hyde Park? For no doubt the air rolled off it, as it does today down Exhibition Road. Even now, if we allow the reaonable deduction of six degrees from the extreme minima in the Kew north-wall screen to bring them to Stevenson standards over the lawn, it appears that quite close to the river screen minima of 37° and 35° have probably occurred (July 1884, August 1890). As regards the possibilities of a rough-pasture park, we may also compare the low

summer minima occasionally recorded in Phoenix Park outside Dublin.

Readers of Parson Woodforde will not fail to envy the generous supply of first-class protein with which he recruited his energies.

University of London,
Bedford College, N.W. 1.

GORDON MANLEY

August Halos

On the afternoon of August 30, 1948, about 16.00 h., there was an interesting though fragmentary halo display. The sky was cirrus and cirrocumulus and above the sun was the faint summit of the 22° halo, and a few degrees above this what seemed to be another arc. I tried to make more precise measurements, but before I could fetch a ruler it was clouded over. I do not think it was what Whipple called Kalmar arcs (Pernter and Exner, Figure 73), as these are in contact; it may have been perhaps an unusual circumzenithal arc. I also see that a halo of 26° is known. In addition, there was one of the finest ordinary circumzenithal arcs I have seen, brilliant and most richly coloured.

Tunbridge Wells.

CICELY M. BOTLEY

A Stormy New Year

Rarely have such wild conditions been experienced in the Isle of Wight as those which prevailed when the New Year literally came in with a roar! Winds reaching Force 10 on the Beaufort scale were officially recorded and they were accompanied by thunderstorms, torrential rain, violent hailstorms and even a little snow! Shipping around the coasts was badly buffeted, while serious damage was done at a Ryde farm and lesser damage at other points, including a trail of uprooted trees, some of which temporarily blocked country roads.

The thunderstorm reached it's height shortly after dusk on Saturday, January 1st and one particularly vivid flash over the centre of the Island was followed by a thunderclap of frightening intensity. People passing over the bridge at Town Gate, Newport, at the time of this thunderclap, saw what appeared to be a ball of fire descend in neighbouring fields. This and a similar incident at Wootton near Ryde appear to indicate that there were instances during the storm of the unusual, dangerous ball-lightning. Wind and lightning played havoc with overhead electricity cables, and every member of the Island high tension maintenance staff of the Southern Electricity Board was out until late on Saturday night and again at first light on Sunday. From observations made by my Father now in his 60th year of residence at Shanklin, and those made by a friend at Ventnor, about 5 miles S.S.W. of Shanklin, the thunder and lightning continued all night intermittently. From approximately 18.00 on the 1st until 07.00 on the morning of the 2nd, when the last flash of lightning was observed, there had been a succession of violent hailstorms which broke windows in many parts of the Island. There appear to have been two outstanding phases of the thunderstorm—one between 17.30 and 18.30 on the 1st, and the other soon after midnight when heavy hail and thunder were noted.

A waterspout burst over the cliffs at Atherfield, near the famous Blackgang Chine, and the accompanying whirlwind severely damaged buildings at Yafford, Shorwell. The noise of the gale suddenly increased at about 17.15 on the 1st to a particularly unpleasant whining roar. Ears were deadened by a great increase in air pressure, and the observer at Yafford was conscious of hearing a considerable crash, and of the house being filled with smoke and dust.

Much damage was done at Hardingshute Farm, on the borders of Whitefield Woods, near Ryde, at about 17.15 on the 1st when a miniature tornado tore the roofs from an 80ft. barn, a cart house and a thatched cow shed. The southern portion of the farmhouse was also extensively damaged, hayricks were partly blown away, and about a dozen trees uprooted while many others had branches ripped off. The severity of the wind strength may be gauged by the fact that the whole of the damage was done within five minutes, at about 17.30 of the 1st, and although it must have been accompanied by considerable noise, nothing was heard in the house but the roar of the wind and the crashing thunder.

At Newport, a resident's pet canary died during the thunderstorm, presumably of fright!

For a winter thunderstorm to continue for such a long time seems to me to be worthy of investigation. What is the cause of this prolongation? Would it be partly due to the still-comparatively warm sea affecting the cumulus and cumulo-nimbus which rolled in unceasingly from South of West up Channel on that unusually stormy night?

London, S.W.10.

J. E. COWPER

CAMBRIDGE UNIVERSITY METEOROLOGICAL SOCIETY

This Society is open to anybody interested in meteorology from any aspect, and resident in the Cambridge area. In November, 1947 it was realized that there was a considerable number of meteorologists, airmen, sailors and others in Cambridge who had acquired an interest in the weather from their war experiences, and in order to stimulate and feed this interest the society was formed with Professor Manley as its first President. Among those who addressed the Society during the first year were Prof. Brunt, Mr. E. Gold, Prof. Sheppard and the current President, Dr. Wormell.

Apart from formal talks, informal meetings are held from time to time to hear papers read by members. An annual outing to some place of meteorological interest is also arranged, the last visit being to the C.F.O. at Dunstable. A visit to Kew Observatory is proposed for this year. Forthcoming meetings will be :—

Feb. 8	Mr. J. K. Bartlett, "Methods of Forecasting the Weather"
Feb. 22	Sir Nelson K. Johnson, "Some Current Problems of Meteorology."
March 8	Lt. Cdr. G. L. Hogben, "Problems of the Forecaster."

Meetings are held on Tuesdays in Lecture Room 4, St. Johns College, at 8 15 p.m during the Autumn and Spring terms only. A small charge of 4/6 per annum or 2/6 until June is made in order to cover expenses. Programmes and Membership cards can be obtained at any meeting, or from the Hon. Sec., G J Bell, St. Johns College. Everybody interested is welcome at all meetings.

THE "DARTON" PRIZE FOR METEOROLOGY

Readers are reminded that Messrs. F. Darton & Co. Ltd. have very kindly offered annual prizes for three years to encourage individual effort in furthering meteorological observation and research The first prize may consist of either a certified Kew pattern Station Barometer or a Barograph or a Thermograph or a Hygrograph. according to the desire of the successful candidate.

This award will be made to the Fellow, Associate or Student Associate of the Royal Meteorological Society who in the opinion of a Committee of the Council submits during the 12 months ending December 31 each year the most useful compact digest of existing meteorological observations, or the results of recent research, to take the form of a paper or article submitted for acceptance in the Society's publications A second prize of a Grass Minimum Thermometer (Sheathed Pattern) will be awarded Papers or articles judged worthy of award, if not already in the *Journal*, will be printed in one or other of the Society's publications. The Society may also print other contributions of sufficient merit.

The first Darton Prize for 1948 was awarded on the occasion of the Annual General Meeting, to Mr. F. H. Ludlam for his valuable digest of recent research, particularly by German authors, on the physics of condensation nuclei and cloud particles, contained in his paper published in the *Quarterly Journal*. The second Darton Prize was awarded to Mr. C. A. Wood for his analysis of weather observations made in the Borneo-Celebes region, also published in the *Quarterly Journal*. The Council further took this opportunity of thanking Mr. Wood for the interesting and very popular articles on various subjects which he has contributed to *Weather*. Dr. J. E. Belasco was commended for his statistical studies of synoptic climatology published in the *Journal* and in *Weather*.

AUSTRALIAN WEATHER

By C. A. Wood

The gale hurled a splatter of rain at the window, and tiny cold draughts scurried under the office door, making the gas fire shiver fitfully. Elizabeth switched off her typewriter and grimaced.

" Deep depression, I suppose. Brr . . . I wish I lived in Australia, where it's nice and warm." She handed me my afternoon cup of tea. " What *is* the weather like in Australia ? Is it always pleasant and sunny, as we usually imagine ? "

" Australia ? Um . . . ", I pondered. " Australia can be as warm as the hearts of its people. If you went to Marble Bar, for example, in the northern part of Western Australia (I reached for an atlas and opened it at the appropriate page), " which is *here*, you'd have enough warmth to last you

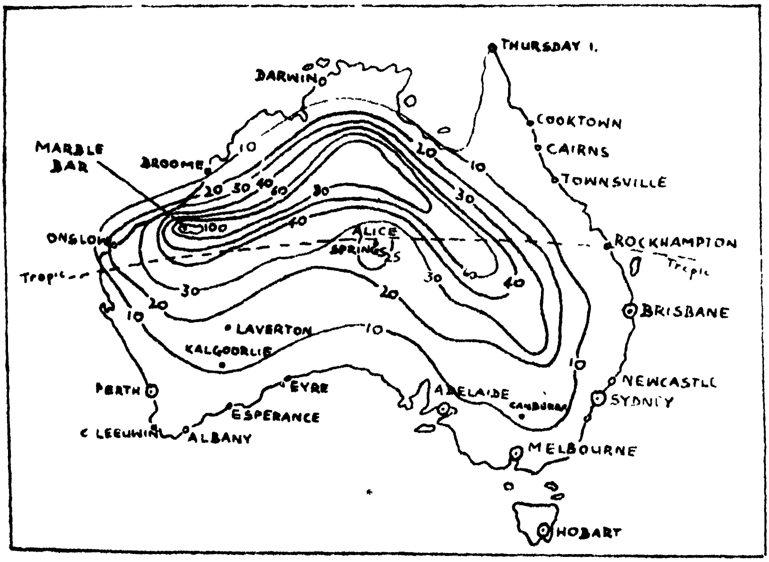


Fig. 1 Area affected and period of duration of longest heat-waves when the maximum temperature for consecutive 24 hours reached or exceeded 100° F. Figures on the lines indicate number of consecutive days.

a lifetime. Marble Bar and the Nullagine goldfields are the hottest part of the continent, and the maximum shade temperature during the summer sometimes exceeds 100° F. continuously for days and even weeks. I think the record for Australia is held by Marble Bar, which during the summer of 1923–24 had over 160 consecutive days with the temperature exceeding 100° F."

Elizabeth sipped her tea. " But that isn't typical of Australia ? "

" Depends on which part of Australia you mean. It's a vast land of many contrasts. The coldest parts are the mountains of the south-east—the Aus-

tralian Alps. One or two places there have in winter recorded zero temperatures, but, mind you, they were at an altitude of over five thousand feet above sea level. You couldn't really call any part of Australia cold in the summer months. On the other hand, the temperature seldom reaches 100° F. in the south-east of New South Wales and East Victoria. The range of temperature increases with increasing distance from the coast, of course, in common with other continents, and the temperatures of the eastern and northern coasts are more equable than those of the western and southern coasts. Southern Australia is subject to frequent fluctuations of temperature as anticyclones and depressions pass."

"Putting it briefly", said Elizabeth, "is Australia warmer than this country?"

My meteorological caution shrank from the direct question.

"The general level of temperature in the coolest parts is well above that of any part of England", I said, guardedly. Elizabeth nodded. "So I thought. What about rainfall and humidity? I see that at Darwin the difference in the means for the hottest and coldest months is only 8·4° F. That sounds equable enough."

"Monsoonal. Darwin is in the tropics, and receives most of its rainfall during the NW. Monsoon, from November to March. That's the southern summer, and a thermal depression develops over Western Australia at this season, bringing tropical rain and thunderstorms to the Northern Territories: north-westerly winds because the circulation around a depression in the southern hemisphere is clockwise."

"So you wouldn't recommend Darwin during the NW. Monsoon?"

"Hardly. Tropical heat and high humidity are very enervating. The tropics are all right if you can live well above sea level, but, as you'll see, Australia has comparatively little high land in the tropics, where it might mitigate the temperature. It's rather a pity that the relief of Australia isn't the opposite way round, with the high ground of the south-east in the north and the lower ground of the north in the south—probably be of more use to the people."

Elizabeth was looking at the atlas. "Actually, the mountains extend north and south, within a short distance of the eastern sea-coast", she commented. "The western interior is really quite high—a great plateau, in fact, from 1,000 to 2,000 ft. above sea level. The plateau extends as far north as 15° S. in the Kimberley division of Western Australia."

"Quite. Now look at the rainfall map, and notice how the rainfall shades off towards the interior. The wheat belt and sheep and cattle distribution are all related to the lines of equal rainfall and temperature—so, too, is the distribution of population for that matter."

"What are the regions of heaviest rainfall?"

"Northern Queensland. With a few exceptions the heaviest rains are concentrated along the Pacific slopes north of latitude 30° S. The orographic effect of the chain of mountains from New South Wales to Thursday Island determines the quantity."

" The SE. Trade blowing against the mountains gives Northern Queensland its heavy rainfall, you mean ? "

" Exactly. Deeral, on the north coast of Queensland, has an annual average rainfall of 183·53 inches, with a maximum of 257·58 inches in 1939. In Tasmania, westerly winds blowing against the high ground of the west have a similar effect : Lake Margaret gets an average of 144 inches of rain a year."

" Sounds *very* wet," said Elizabeth, watching the rain trickle down the window. " What's the wettest place in this country ? "

" Pass me the 1946 volume of *Weather*—yes, No. 1 . . . " I turned the pages rapidly. " Here we are : Gordon Manley's article on Seathwaite, in Cumberland—' the wettest inhabited place in England '. Had 182·6 inches in 1861."

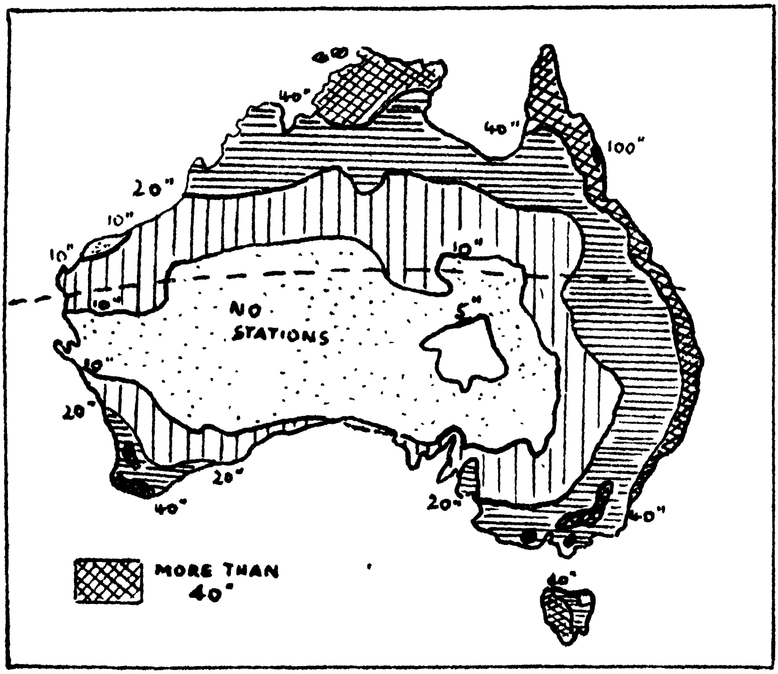


Fig 2 The rainfall of Australia.

" I know of a wetter place ", said Elizabeth thoughtfully. " Last year, when we were camping out in Glen Affric, it simply poured down."

" So I believe. Not to the extent of 182·6 inches, though. Anyway ", I added, unsympathetically, " you shouldn't go camping out in Scotland when the Polar Front is up to its tricks."

Elizabeth made a face. " You were expecting an anticyclone when I asked you for a forecast before I left ", she said, with spirit.

" Um . . . was I ? " I returned to the atlas hastily. " Well, let's get back to Australia. Have a look at the rainfall column in the tables of climatological data for Australian capital cities. Sydney takes chief place, with a normal rainfall of 46·59 inches, followed by Brisbane, Perth, Melbourne, Hobart,

Canberra and Adelaide, in that order. Adelaide is the driest, with 21·18 inches. Over here, Kew Observatory measures 23·86 inches."

CLIMATOLOGICAL DATA. AUSTRALIAN CAPITAL CITIES COMPARED WITH KEW.

	Height above M S L feet	Prevailing wind*		Annual Averages					
		9 a m.	3 p m	Hours of sunshine (total)	Inches of rain (total)	Temperature Mean max.	Temperature Mean min	Temperature Mean	Relative humidity % 9 a m.
Canberra	1906	E	NW.	2453 3	23·05	67·7	44·1	55 9	70
Perth	197	E	SW	2833·0	34·75	73·4	55·4	64·4	61
Adelaide	140	NE	SW	2532·3	21·18	72 8	53 2	63·0	53
Brisbane	134	S.	NE	2710 7	44·71	78·0	59 8	68·9	68
Sydney	138	W	ENE	2470·1	46·59	70·3	56 2	63·2	70
Melbourne	114	N	S	2046·8	25·69	67 4	49 6	58·5	69
Hobart (Tasmania)	177	N -NW	SE	2145·0	23·96	62 2	46·5	54·4	67
Kew Observ	18	SW.	SW	1469·0	23·86	57·0	43·8	50·4	80

Note sea-breeze effect

"Figures are confusing", said Elizabeth. "Can't you generalize a little?"

"It's dangerous to generalize. Still, I suppose you might say that approximately one-third of the area of the continent, principally in the eastern and

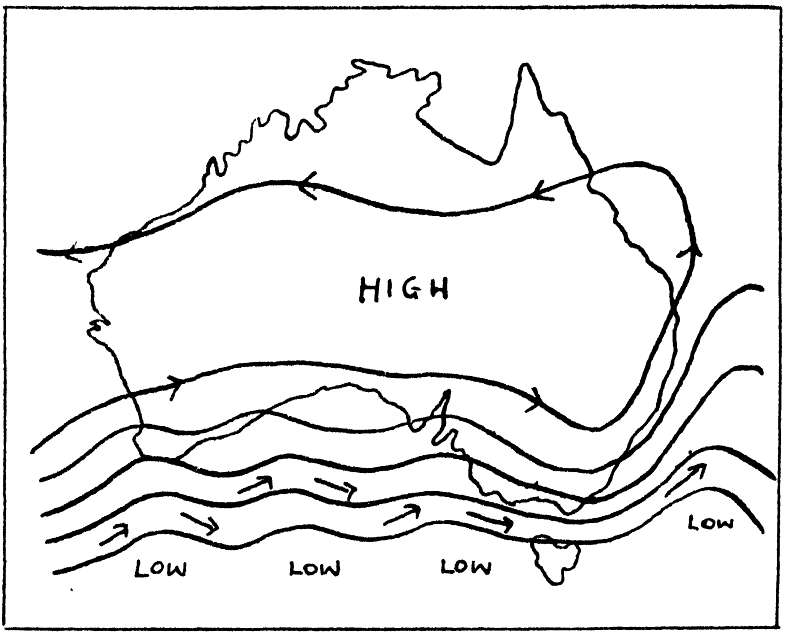


Fig 3 Waves of low pressure
A frequent Australian synoptic situation in winter and spring.

northern parts, enjoys an average annual rainfall of from 20–50 inches or more, while the remaining two-thirds average from 5 to 20 inches."

A door banged. The gas fire shuddered. Elizabeth said:

" So the northern parts of Australia get much of their rain from tropical rainstorms during the warmer half of the year, from November to March. What about deep depressions—don't they have them in Australia ? "

" Most decidedly they do ! In South-Eastern Australia deep depressions occur at any time of the year, but only a moderate proportion are accompanied by severe weather. Even in the late autumn and winter months the great anticyclones give fairly frequent interruptions to the sequence of true wintry weather. However, it is during the winter months—June to August—that the depressions come into their own, at least over Southern Australia and Tasmania. They're the chief factor in wheat-growing, incidentally. They move from roughly WNW. to ESE; or SE. compare that with the general WSW.—ENE. track of depressions across our own country. The Australian

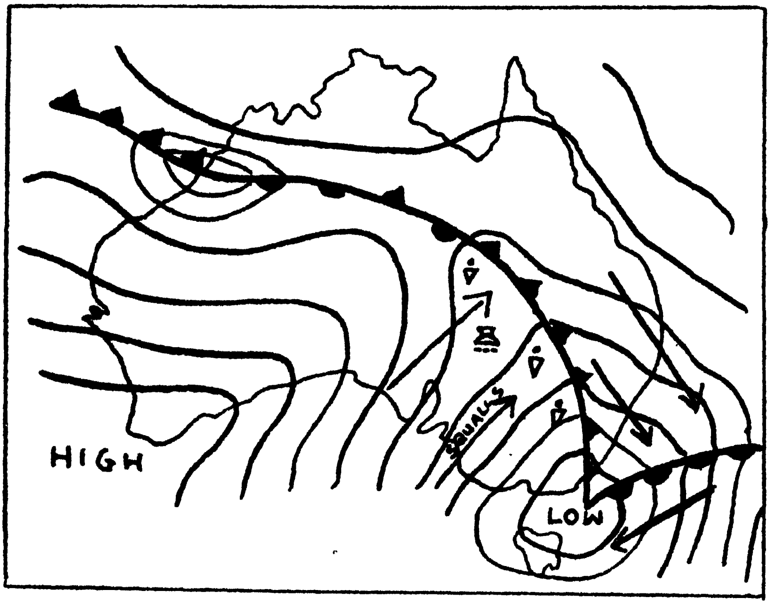


Fig. 4. " Southerly Burster."
(Australian summer Phenomenon.)

depressions look just like the northern hemisphere ones on a synoptic chart, and they have the same cloud and weather sequence, but they're upside down as it were. V-shaped depressions become A-shaped in the southern hemisphere, rather like this . . . " I sketched one on a piece of paper. "A trough of low pressure resembles one of our ridges of high pressure in shape. It's a bit confusing at first. The warm wave which provides the warm sector of the Australian depression comes from the north, not the south, and southerly or south-westerly winds from the Antarctic sweep in behind the cold front, giving showery conditions after the style of our unstable polar-air northwesters. With a particularly sharp temperature contrast between the warm and cold air masses, violent squalls, thunderstorms, and heavy rain develop along the cold front as it progresses eastward across Australia. In the summer half of

the year the New South Wales coast is sometimes affected by such phenomena, and the name " Southerly Buster " is given to the southerly change as it moves eastward along the coast."

Elizabeth looked at the sketch critically.

" Does it ever snow ? "

" Occasionally. Light snow has been known to fall as far north as 31° S., in New South Wales particularly. The Australian Alps have a snow-cover for several months during the winter. The southern shores of the continent receive a lot of hail, too—the heaviest hailstorms occur in summer, and the stones sometimes exceed the size of a hen's egg. A particularly heavy hailstorm occurred at Charleville on November 23, 1947 : the wind reached 66 m.p.h., and pieces of hail picked up at random measured over five inches in circum-

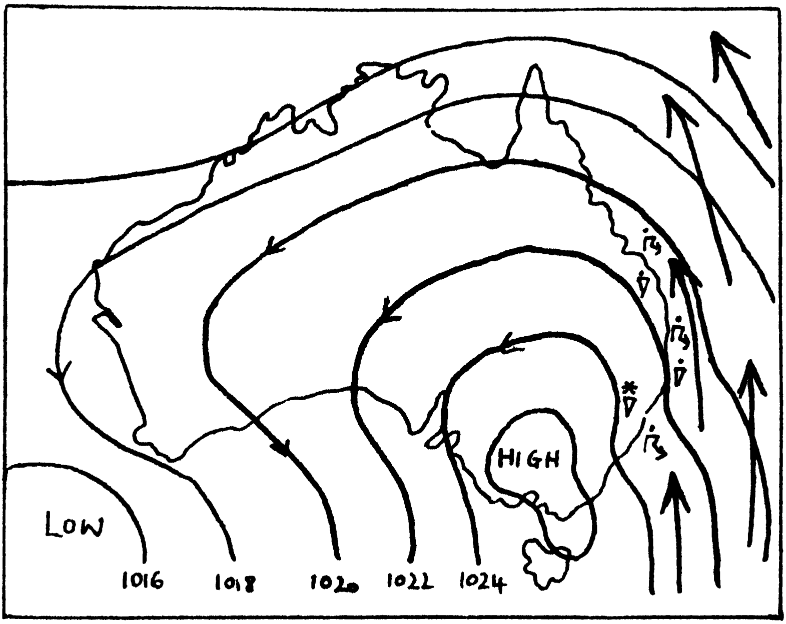


Fig 5 Penetration of cold southerlies to tropics.
Thunderstorms and frequent showers on windward coasts, snow on eastern highlands.

ference. All glass windows facing north-west, west, and south-west were shattered, and all wooden and canvas blinds with the same aspect were torn and broken. Some iron roofs were perforated, and all were badly buckled and torn away from their nails. Twenty-four people suffered bruises from hail, and some received cuts from breaking glass. Every garden and orchard in the area was completely destroyed, and thousands of head of poultry were killed, as well as some dogs and cats. The town council estimated the damage at £150,000. No joke getting caught in an Australian hail shower ! "

" I expect the insurance companies have a bad time ", said Elizabeth, " after such a storm. How about tropical cyclones—willy-willies, don't they call them ? "

"Um . . . yes. They occur chiefly on the NW. coast of Australia from November to April: the NW. Monsoon period. They seem to originate in the ocean in the vicinity of the Cambridge Gulf, and they move in a south-westerly direction, intensifying as they go, rather like the typhoons of the China Seas. Onslow sometimes suffers from these storms, which cause great havoc amongst the pearl fishers. After leaving the NW. coast, the storms either travel southward, or cross the continent to the Great Australian Bight, bringing torrential rain to some inland regions of the Northern Territory: as much as 29·41 inches have been recorded at Whim Creek in 24 hours. In the late summer and

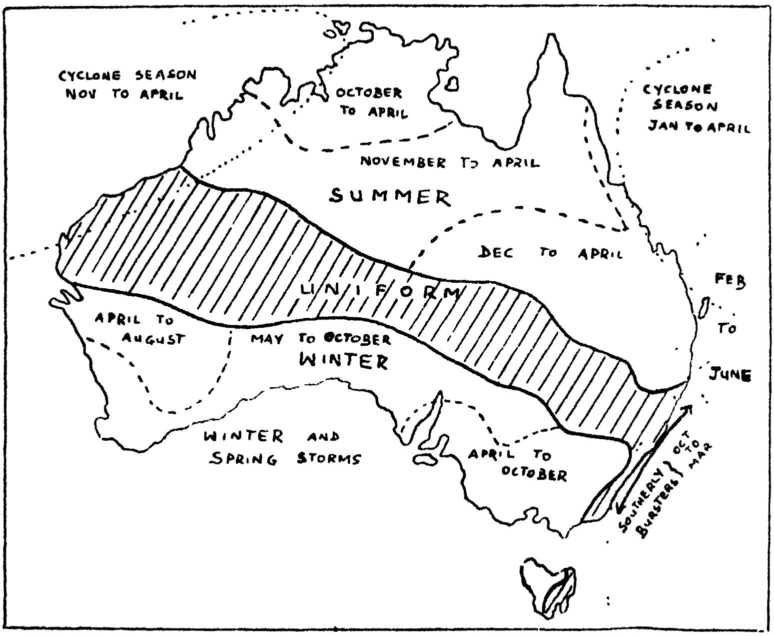


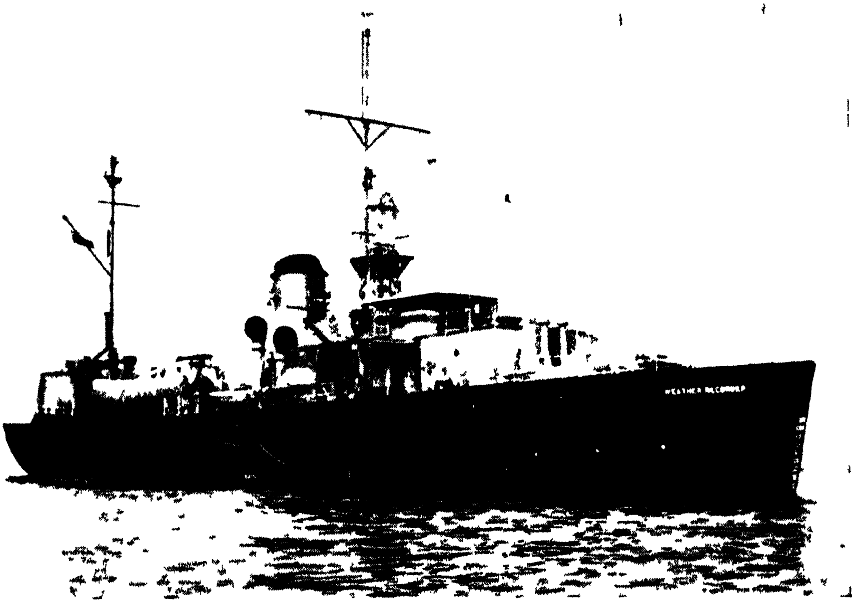
Fig 6 Australian rainfall—seasonal distribution

early autumn, tropical cyclones of equal severity are experienced on the Queensland coast—they are born in the Coral Sea, and move in from the NE. and recurve to the SE. towards New Caledonia. Heavy floods and serious damage sometimes accompany these visitations."

Elizabeth closed the atlas and picked up the cups.

" I think I'd rather put up with our deep depressions ", she said, turning to the door. I looked through the streaming window at the ragged fractostratus scudding over the chimney-pots, and my mind was far away.

" Such phenomena are only exceptional items in the great catalogue of Australian weather, and it would be wrong to take them as typical of the general climate. It isn't all southerly busters and cyclones and rain, you know. You should see the surf at Bondi Beach, and the Blue Mountains in summer, the Perth regatta, and the corals of the Barrier Reef. Hot dry sands, sparkling

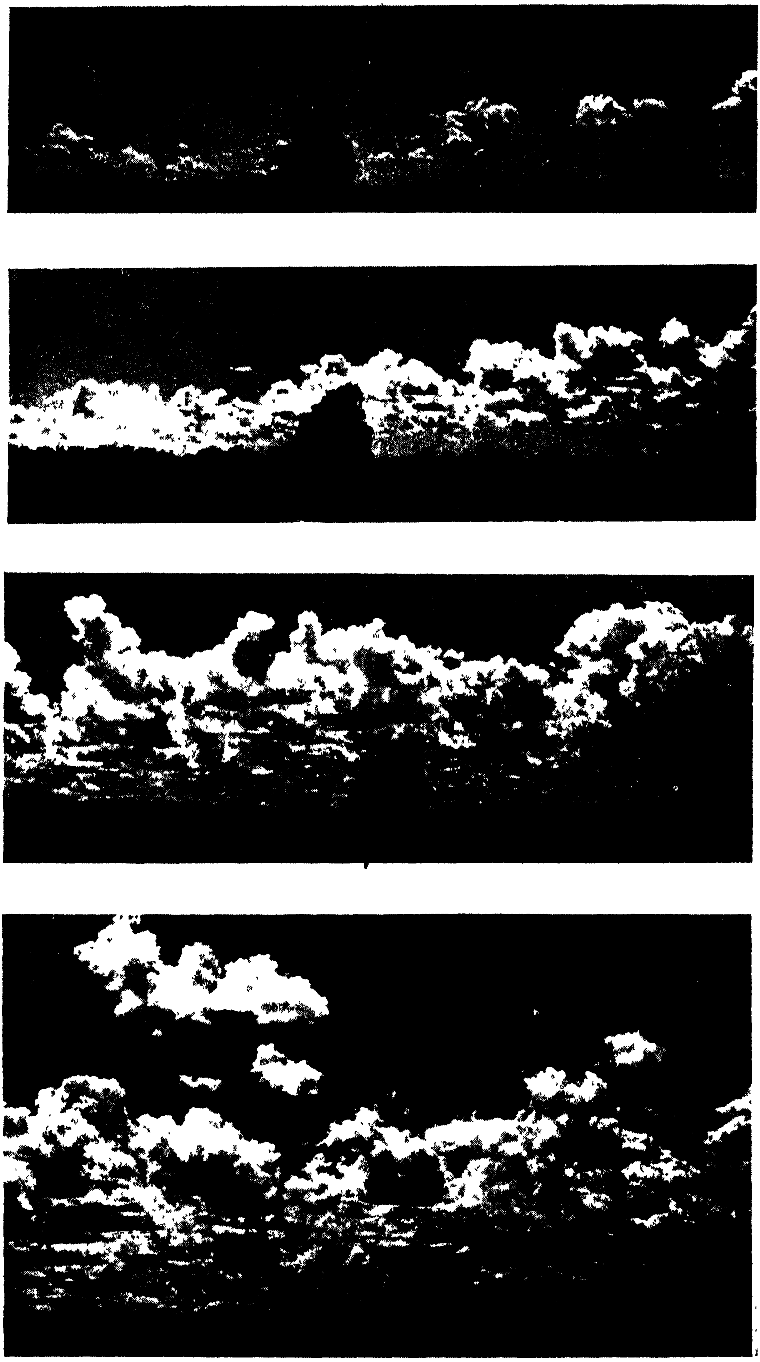


O.W.S. *Weather Recorder* at station Jig, July 1948
Taken from rubber dinghy

Late evening at station Jig, 20th July, 1948

Photographs by] [*O. M. Ashford*

PLATE III



Cumulus cloud sequence in Australia

PLATE IV

seas, creamy foam . . . "

Elizabeth's eyes danced mischievously.

" Maybe you ought to open a travel agency ", she said.

ACKNOWLEDGMENTS

I desire to acknowledge with thanks the helpful criticisms made during the preparation of this article by the Director of the Commonwealth Bureau of Meteorology, Melbourne, and his kind permission to use facts, figures, and diagrams from the *Official Year Book of the Commonwealth of Australia,* and other publications. I would also like to tender my thanks to Mr. W. Milthorpe, the Weather Officer of Charleville Aerodrome, from whose account in the June 1948 issue of the *Weather Development and Research Bulletin* the description of the hailstorm at Charleville on November 23, 1947, is taken.

A DAY IN AN OCEAN WEATHER SHIP

By Captain A. W. Ford

" Weather Ship Jig, Weather Ship Jig, this is Swiss Air Item, how do you hear me ? "

" Good evening Swiss Air Item, you are coming in strength five."

" Good evening Weather Ship Jig, I hear you five by five. My position at 2210 zebra 53 20 North, 17 50 West. I fly at 9,000 feet. I left Shannon Airport at 2005, estimate Gander, Newfoundland at 0729, course 300 degrees, true air speed of 155 knots. Can you give me a radar fix please ? "

" Swiss Air Item from Jig. You bear from me by radar, 180 degrees, 100,000 yards at 2220 zebra. Our position is 3 miles 280 degrees from station Jig. The wind at 9,000 feet from an observation taken at 2,000 zebra, 345 degrees, 45 knots, temperature 41 degrees Fahrenheit, freezing level 14,000 feet. Our beacon is on for you. Please stand by for a further radar fix. Over."

Three hundred and sixty-five days a year and twenty-four hours in every one of those days. I wonder if the " man in the street " realizes the enormous amount of work that is carried out in a weather ship during each of those twenty-four hours, so that a Swiss aircraft can have the latest available information to help him on his way and that we can contribute our quota to the world-wide meteorological network.

To maintain a twenty-four hour service, the ship's company of fifty-two must necessarily be divided into three watches, which means that there is always a duty watch of one bridge officer and three seamen, one engineer officer and two stokers, two telegraphists and a radio/radar mechanic, and a meteorological officer assisted by two observers.

Primarily we are on station in the Atlantic to observe the weather, the result of our observations being passed to Dunstable. These observations together with hundreds more are plotted, the result being a comprehensive

weather map. Surface observations, wind, barometric pressure, temperature, humidity, cloud formations and the state of the sea, are observed every three hours. The upper air is observed at six-hourly intervals by sending aloft a radio-sonde balloon, from which we can find the barometric pressure, humidity and temperature at any altitude. By tracking the balloon, from which a radar target is suspended, the direction and speed of the wind can be measured. The meteorological staff have a busy time : no sooner is one observation completed than preparations are being made for the next. In between times, experiments are carried out with new or impróved instruments.

In addition to our meteorological function, a twenty-four hour service to transatlantic aircraft is provided, a service which is becoming increasingly popular as the months pass by. This service consists of a medium-frequency radio beacon which transmits our call sign for six minutes every twenty minutes, a radar fix upon request, providing of course that the aircraft is within range, the latest available meteorological information for the height at which the aircraft is flying and the corrected surface pressure in order that the pilot can check his altimeter. As soon as the upper air data are available, they are passed to the navigation bridge and posted on the aircraft-control table. The duty officer handles aircraft by radio telephone. From the aircraft-control table the officer can speak to the aircraft, plot the position, course and speed of the aircraft, direct the radar with the intercommunication loudspeaker and contact various parts of the ship by eight telephones.

When the aircraft ' comes up ' on the R/T the radar begins its search, while the duty officer logs the aircraft's flight plan and ' passes ' the upper wind for the altitude of the aircraft. If the aircraft is within the range of the radar, sixty or seventy miles, a ' fix ' is passed and further fixes are sent until the aircraft is our of range.

One of two aircraft on the air at the same time present little difficulty, but we have had as many as six. Then the fun begins. Of course they have to take their place in the queue, but each invariably wants a radar fix. By plotting each aircraft they are soon sorted out, and each receives the correct fix. If there is any doubt, the aircraft is requested to pass the bearing of our beacon and the reciprocal of the bearing is checked against the correct radar bearing.

To give some idea of the ever-increasing popularity of this service, a quick glance over the past year will not be amiss. During the first three voyages when we were settling down and getting organized, serving our apprenticeship as it were, little was heard of passing aircraft, a matter of a dozen or so being contacted each voyage. The fourth voyage, in March 1948, saw an increase in contacts, the net total being forty seven aircraft of divers nationalities. In April, during the same period of twenty-one days, the period we remain on station, the number increased to one hundred and two. A month later saw a further increase, a total of one hundred and eighty-eight aircraft being logged. During the seventh voyage, in July 1948, the previous record of one hundred and eighty-eight was passed after having spent only

thirteen and a half days on station, the total at the end of the twenty-one days reaching the huge total of three hundred and one aircraft. One feels that the white masthead lights common to all ships should be replaced by the green, amber and red traffic lights.

We are naturally very friendly with these aircrews: we soon get to know each other. Last winter I had the pleasure of entertaining a group of Scandinavian airmen from Prestwick airport; over the odd noggin one of the pilots told me how much extra confidence it gave the aircrews to feel that we were there. This is very understandable—the Atlantic is a long stretch of water!

This service to aircraft is a really good thing, not only from the point of view of the aircraft, but also from our own. It really keeps us on our toes, and it's a lot of fun working these transatlantic 'planes, American, Dutch, Scandinavian, Swiss, French, Belgian and Canadian, in addition to our own B.O.A.C. They are very appreciative of the service. It makes us feel as if we would like to do more.

The radar is one of the means by which the aircraft obtains a position, but there are times when the range of the radar is very limited. On the evening of the July 16, 1948, an evening of continuous drizzle and heavy nimbo-stratus cloud, the radar had the greatest difficulty in penetrating the atmosphere. The cloud ' clutter ' was exceptionally heavy which made it very difficult to distinguish an aircraft echo on the radar display unit. Even after an echo had been located the maximum range was reduced by some 25%. It was noticeable in the early hours of the following morning, when the ' front ' had passed through and the nimbo-stratus had given way to stratus and fracto-stratus, that the radar was once again giving maximum ranges.

To act as a beacon and enable aircraft to take bearings with confidence, the ship must keep close to station, accurate navigation therefore is of paramount importance. Astronomical fixes of the sun, moon and stars are obtained whenever possible, but on occasions, days pass without a glimpse of clear sky. The longest we have been without celestial observations is three days, three days with continued southerly weather. In July 1948, with continued anticyclonic conditions, sun sights were obtained four times daily but stars were only visible one night in fourteen. However, the state of the sky does not prevent us obtaining a good position, as we are fitted with Loran, an electronic aid to navigation, which provides a position within a couple of miles. This, together with the aid of Consol, another electronic aid at our disposal, makes station keeping very simple. These aids are checked against astronomical fixes, the results being sent to the Ministry of Transport who are conducting a research into electronic aids to navigation.

As a further service to transatlantic aircraft, the ocean weather ship is fitted with the very best of equipment for air/sea rescue. This equipment would be of little use without trained personnel, so training in this branch of the service is taken very seriously and is part of the established routine. Frequent exercises are carried out with shore-based aircraft of the Royal Air

Force. In addition to the valuable training these exercises provide, the R.A.F. drop newspapers and personal mail for the ship's company, a practice which adds zest to the entire operation.

Finally we do a little fishing for the Ministry of Agriculture and Fisheries. To and from station we tow a recorder which collects plankton, minute organisms on which fish feed. When on station a silk net is suspended over the side. The plankton is bottled and sent to the laboratory of the Ministry when we return to the base at Greenock.

All this adds up to a very busy day, the engineers keeping the engines in first class condition, the radio/radar mechanics maintaining the enormous radio installation and the radar, the radio telegraphists keeping in touch with the outside world, the meteorologists observing the weather, the crew keeping the ship spotless, balloons going up, aircraft coming in it is a small wonder that the social hours in the evening mean so much. In the officer's smoke room a couple of bridge schools are usually under way. F'ward the petty officers and the crew each have their own recreation room, with a dart board, games and a library. But the best of all, the *pièce de résistance*, is our cinema. A complete programme consisting of a full-length feature and a short is shown each week at three different times, to enable all watchkeepers to see it. The radio broadcasts throughout the ship keep each of us in touch with the outside world.

The twenty-one days are very busy days, and we are indeed very ready for some leave when we arrive back at the Great Harbour, Greenock.

Erratum

Weather, January 1949, page 6, line 27; *for* defined by equation (6.6), *read* suggested by the inequality (5.4).

METEOROLOGY AT THE ROYAL SOCIETY OF ARTS

Captain J. W. Josselyn, D.S.C., R.N. (Ret'd), lately Director of the Naval Meteorological Service, gave a lecture at the Royal Society of Arts on January 11, 1949 on "Weather Forecasting at Sea."

He began by pointing out that the technique of forecasting the weather at sea differed from that employed ashore for two fundamental reasons. Firstly, the amount of data available to the forecaster afloat was, in general, very limited. Secondly the requirements at sea were much simpler than those ashore. Cloud height, icing index and freezing level were of no importance to those in ships ; the important factors were wind and visibility. High winds raised heavy seas which inflicted damage and upset time schedules. Fog caused loss of time and created danger of collision, especially in pilotage waters. Precipitation was important only inasmuch as it reduced visibility.

The forecasting of wind in middle latitudes implied estimating the movement and development of depressions. The lecturer gave a simple account of polar-front theory, the mechanism of pressure change and their application. He stressed the value of upper-air data and showed a rough method of estimating the pressure pattern aloft, based on the assumption of a standard lapse rate of temperature.

Turning to the subject of tropical storms Captain Josselyn stressed the scarcity of observations in their immediate neighbourhood as Captains naturally took avoiding action at the first sign of trouble. A swell, increasing with time, was often a useful prognostic in the absence of more direct data. Forecasting rules were based on the general experience that these storms drifted in the easterly winds on the equatorial side of the semi-permanent high pressure areas of low latitudes and eventually curved polewards They might then become transformed into the depressions of temperate latitudes. The lecturer illustrated an example in which the use of upper-air data was held to be of vital significance to the successful forecasting of the unusual track followed by the storm.

Mentioning the occasional occurrence of strong winds at the perimeter of anticyclones, Captain Josselyn cited the historic occasion in June 1944 when, on the Normandy beaches, they were strong enough to imperil the success of landing operations.

The formation and occurrence of fog was briefly discussed. There were three types of fog, advection fog formed by warm air blowing over a cool sea ; radiation fog, forming over land and drifting out to sea ; fog due to mixing between two air masses. This latter type of fog was rare : in fact Captain Josselyn remarked that in his long experience at sea he had only met with it twice, once off the coast of Scotland and once in the Red Sea.

Captain L. G. Garbett, C.B.E., R.N. thanked the lecturer on behalf of the meeting.

THE WEATHER OF JANUARY 1949

MILD AND DRY

Other than in West Scotland the month was remarkably dry, parts of Southern England recording less than one half of the normal (e.g., Falmouth had only 32mm. while the average is 107). Apart from a short cold spell from 3rd to 5th when some maximum temperatures in Scotland did not rise above freezing point, the weather was mostly mild, especially during the middle of the month when minimum temperatures above 45° were common.

The month opened with an exceptionally low pressure over Ireland which moved eastward, 950 mb. being recorded at Holyhead. North-westerly gales were blowing for 1,500 miles or more to the westward of this depression but winds were not as strong as might have been expected to the south-eastward because pressure was low over Central and Western Europe. The extremely unstable air behind this system together with the relatively high sea temperature in the Channel contributed to widespread thunder and lightning off the South Coast and other manifestations of instability (see p. 52). A cold air mass covered the British Isles for the next three days and temperatures were especially low in Scotland, Dyce (Aberdeen) recording minima of 18°F. on 4th and 13°F. on 5th and maxima of 32°F. and 30°F. on 3rd and 4th respectively.

By 6th a westerly type was established and milder weather was resumed until 8th when there was a severe north-west gale over Scotland and northern England followed by low temperatures on 9th. For the next fortnight pressure was high to the south-west of the British Isles and a westerly type prevailed with rain at times in the north-west though mostly dry elsewhere.

On 24th an anticyclone was established over central Europe and a southerly type became general. Fog became increasingly widespread in much of England and Wales and persisted locally all day: in parts of London for example it was particularly thick on 28th and 29th. Temperatures were fairly low all day in the foggy areas, but exceeded 50°F. by day in the west On 30th another anticyclone moved eastward over Ireland from the Atlantic; weather over England was rather cold and cloudy while Northern Scotland experienced a gale due to a deepening depression over Southern Norway. On 31st there was scarcely any sunshine and slight rain over much of the country associated with a wave moving south-eastward over the North Sea, despite an anticyclone centred over south-western districts and a pressure of over 1032mb. from Lands End to John o' Groats.

	TEMPERATURE (°F.)				RAIN (mm.)*			SUNSHINE (hr.)		
	Long period Average		This month Extreme		Month	Diff. from Av.	Last 12 months	Month	Diff. from Av.	Last 12 months
	Max.	Min.	Max.	Min.						
Kew Obsy.	45·2	37·5	53	28	23	−27	478	55	+11	1547
Gorleston	44·3	36·8	52	30	31	−13	479	76	+20	1711
Birmingham	43·2	36·0	51	30	35	−16	774	44	0	1373
Falmouth	47·7	39·9	†55	†36	32	−75	878	83	+23	1713
Valentia	49·0	42·3	55	32	89	−65	1326	55	+11	1259
Aldergrove	43·3	35·4	52	25	63	−17	819	33	−9	1299
Holyhead	46·4	41·6	52	29	61	−13	732	39	−12	1547
Tynemouth	44·1	37·3	54	27	22	−19	540			
Renfrew	43·6	35·3	53	17	118	+33	1296	25	−9	1214
Aberdeen	43·0	35·0	56	13	49	−10	778	75	+23	1458
Stornoway	44·6	37·8	51	19	154	+7	1257	21	−6	1224

* 25 mm. = 1 inch (approx.) † The Lizard C.R.B.

MARCH 1949

WEATHER

Vol. IV
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CONTENTS

EDITORIAL

Climatologists and synoptic meteorologists alike will find much of value in the report on page 71 of a lecture by Professor C. G. Rossby on the circulation patterns of the atmosphere. The vision of new horizons in climatology inspired by this article may arouse interest in the subject among synoptic meteorologists who have hitherto been somewhat reluctant to exploit climatological techniques. Perhaps one reason for this reluctance is that meteorology is still regarded as a child of physics and that most synoptic meteorologists are not trained in the statistical procedure necessary for the study of an *observational* rather than an *exact* science. This is one of the themes discussed in a paper by E. Rosini, reviewed on page 80.

It must be admitted that much in climatology appears trivial and academic. Current methods are not always well adapted to provide the type of information required by the forecaster, the industrialist, the engineer and other potential users. This can be remedied by the application of more advanced statistical techniques and by the adoption of the spirit and method of operational research. Dr. C. E. P. Brooks, whose life and work are described in this issue, is in the forefront of the movement to promote the use of statistical methods in meteorology.

The rapid collection of upper-air data is providing a new and immense field, and this latest branch of climatology will benefit the synoptic meteorologist. Already, the need for climatological techniques is being felt in upper-air work. Climatology may be regarded, in this connexion, as the systematic and scientific method of benefitting by experience, replacing the hazy and ill-expressible experience of the individual.

It is sometimes remarked that mathematicians turn to the study of philosophy in their old age ; can we hope that synoptic meteorologists will one day turn to the study of climatology ?

WEATHER SENSE OF BARTIMAEUS

By William Grubb

You have often met us on the road in all weathers cautiously threading our way among our unseen fellows, our bodies taut and our ears strained to catch sounds that will guide us in the invisible maze, but what you think on these occasions is anybody's guess. However, your spontaneous and unfailing help are in marked contrast to that fickle jade, the English climate, which is often more of a hindrance than a help as we go about our daily adventure. You may wonder how we find our way at all. The answer is by feeling, hearing, sometimes by smelling—when our path takes us past a brewery, for example—and above all by memory. When I arrive in a new district I soon learn to go by myself to such important places as the Post Office, the tobacconist's and of course the " local " ; I count the number of openings, discover which way to turn at the corner and locate by painful experience the awkwardly placed lamp-post or pillar-box.

Like you (I imagine) our moods are rarely uncoloured by the weather when we are actually outside, but often its influence is insignificant. Cold tends to make us serious and, if thin blooded, miserable. Great heat of course breeds idleness, consequently gloom and a low moral threshold. But in either case intellectual or social counter-stimuli can easily triumph.

I think that we must be less affected by the weather than others when indoors, not that we are totally insulated ; strong sunshine coming through a window or the sound of wind and rain outside makes us, with others, respectively very discontented or contented to be where we are. For us there is no looking at the weather through the bedroom window first thing in the morning—which often reduces the temperature of a sighted person to zero ! I often chuckle when it comes to reading in bed on a cold night ; while my seeing friends are trying all kinds of dodges to keep their fingers warm while holding the book and turning the pages, I have my Braille volume snugly under the blankets !

Our chief enemy among the elements is snow, in which all sound is muffled and indefinite, and all irregularities in the surface are filled in. As our feet are as sensitive as our hands, we miss the familiar curves, hollows and edges, which are our usual guides to our destination, and we sometimes find ourselves ankle deep in the snow, having missed the kerb.

As for the rain, a good heavy shower can be a real friend to the blind as it clears the pavement of such obstructions as gossiping groups, prams, tricycles —not to mention queues ! We can then swing along more confidently, though not seeing the puddles we often return home with wet feet.

The wind can be either a help or a hindrance ; a following wind seems to carry the sound away from us, while a head wind brings the sounds clearly to our ears. In a light breeze we can sense when we are passing an entrance, an open space or coming to a street corner by the associated changes in the flow of the air. In a gale, however, as in the snow, we have a sense of being completely lost and isolated.

There is one weather condition in which we are in our element ; I refer

to a typical London pea-soup fog, in which the blind become the leaders of the blind and we are sometimes privileged to lead our fellow travellers safely to their street and even to their own doorstep.

In the keen clear air of a winter day we are especially happy, for all sounds are crystal clear and their direction unmistakeable. But, as I said at the beginning of these imperfect notes, the ready and cheerful help of the countless Good Samaritans all over the country makes victory over blindness possible and enables us to triumph completely over the weather.

METEOROLOGY AT THE ROYAL GEOGRAPHICAL SOCIETY

Many meteorologists, at the invitation of the Royal Geographical Society, had the pleasure of hearing Professor C. G. Rossby lecture on Monday, January 24. His subject, *Circulation patterns of the free atmosphere and their climatic application*, proved of absorbing interest to both meteorologists and geographers.

Professor Rossby began by referring to a recent study by Willett of the circulation of the atmosphere in relation to climatic fluctuations. This study had led to the conclusion that the climatic changes of post-glacial times, as well as short-term variations, could be explained in terms of the contraction or expansion of the polar vortex of westerly winds aloft. An expansion, for example, led to a displacement of the climatic belts towards the south and an increase of the N-S wind components in the atmosphere. The immediate problem, therefore, was the exploration of the circulation patterns of the free atmosphere. Professor Rossby's own studies of atmospheric flow patterns had emerged from an investigation into the occurrence of drought. He remarked that this investigation had been undertaken on the strict understanding that there would be no "cure"!

In any study of the general circulation there were two lines of attack available for eliminating the small-scale perturbations that masked the broader pattern; in other words, of filtering out the circulation patterns. On the one hand there was the statistical method which involved the construction of mean charts covering a period long enough to ensure the elimination of the transitory depressions; on the other hand there was the hydrodynamic filtering method which consisted of the use of upper air charts. These charts showed intrinsically simpler patterns than the surface synoptic charts and were ideal for the study of circulation patterns. Unfortunately, at the time the study of the general circulation was started it was not possible to construct upper-air charts in the requisite detail and the statistical filtering method had perforce to be adopted. Mean charts were drawn, as a routine, for periods of either five or seven days, using Northern Hemisphere circumpolar charts—of a similar type to the familiar *Daily Weather Report*. These charts showed a large-scale pattern from which the individual depressions of the surface synoptic charts had been smoothed away.

The study of a large number of charts led to the concept of the zonal index. It was found that some charts showed a very strongly developed polar vortex of westerly winds. At these periods maritime influence on the American and European continents was at a maximum. Winter temperatures in W. America and NW. Europe were higher than normal, and so was the rainfall. The term ***high zonal index*** was coined to denote this atmospheric state of an intense polar vortex with its associated temperature and rainfall anomalies. Other charts showed the zonal circulation broken up or blocked by large-scale highs and lows. The westerly winds were much less in evidence and strongly developed northerly and southerly currents were found. On these charts the Siberian high in winter was displaced well to the west of its normal position and negative temperature and rainfall anomalies were evident in NW. Europe in winter. The term *low zonal index* was applied to a pattern of this type. These two types represented extremes between which the state of the atmospheric circulation fluctuated. It was found possible to use these charts to deduce in a general way the flow pattern aloft and for these general patterns Professor Rossby had derived, from theoretical considerations, a simple relationship between the strength of the zonal wind, the speed of the wave and the wavelength of the sinusoidal pattern. In the last stages of the war, when more upper air data became available, it became possible to use the more direct method of hydrodynamic filtering. The results fully confirmed the deductions derived from the statistical method.

Professor Rossby then mentioned that he had just been reading an account of a discussion on the application of meteorology to aerial navigation and had been amazed at the omission of any reference to the exceedingly strong winds that were found in narrow zones over the North Atlantic. Dr. Palmén had studied the distribution of wind and temperature in cross sections of the atmosphere taken along a line running approximately north to south through the eastern U.S.A. These cross sections showed the enormous concentration of the westerly wind component in a narrow jet, with maximum speeds up to 150 metres/sec.

Professor Rossby then went on to talk of the instability of the long waves in the Westerlies. By means of synoptic charts he showed how on some occasions depression after depression followed the same track conditioned by the wave pattern aloft and then a change took place and the process broke down. It was as if the individual depressions were trucks travelling on railway tracks one after the other; this continued until someone came along and pulled up the tracks. This instability led to the cutting off of cold lows and a re-establishment of the zonal current further to the north. The importance of circulation patterns for climatology was admirably illustrated by a slide showing how the distribution of rainfall over NW. Europe was related to the flow pattern aloft.

The application to climatology of the results of the study of the circulation patterns of the atmosphere rested on the assumption of the basic similarity of the fluctuations of the zonal index irrespective of the time scale. Valuable

information on long-term fluctuations might therefore be obtained from the study of short-term fluctuations.

In the discussion which followed, Sir Nelson Johnson asked if there were any indications which might be of assistance in forecasting the position of the jet streams. Professor Rossby thought that it was usually possible to indicate the general area but not the precise location of a jet stream ; sometimes there were several jet streams. The important point to be brought home to all navigators was the *non-linearity* of the wind field.

Mr. E. Gold said that many of the problems discussed by Professor Rossby had been in mind for many years but had never been propounded in such a definite fashion. He thought that the only hope of forecasting jet streams was on the basis of temperature distribution. In the new conception of climate, average values of the different elements were no longer sufficient ; we now needed climates of the different circulation patterns. He had found the lecture most stimulating—much more so than the alcoholic stimulants available at the present time !

Professor Gordon Manley remarked that the lecturer had reminded us that the present is the key to the past. During his own investigations into the instrumental records of temperature over the past 200 years, he had concluded that the range of variations was of the same order as that in the post-glacial period. He wondered if prolonged periods had occurred when the zonal index was consistently high or low. Professor Rossby replied that he regarded the zonal index as fluctuating between two extremes, but that there were some periods when it had been predominately high and vice versa.

In replying to Dr. P. R. Crow, the lecturer said that he had no detailed knowledge of the statistics which showed that in the Denmark Strait and Iceland area the tracks of depressions were further south in summer than in winter, but he thought that the general explanation must be that there was a greater possibility of a low circulation index during the winter.

Mr. L. C. W. Bonacina stressed the importance of regional geographical features, which must play a part in determining or modifying the circulation patterns. In expressing agreement, Professor Rossby confessed that he had not mentioned a serious weakness in the theory of the long waves—whence did they derive their energy ? It was possibly here that the surface came into the picture. He also agreed with Mr. H. H. Lamb who suggested that there might be a geographical influence on the location of the cutting off of cold lows ; it seemed that the geographical control became effective through resonance.

The Chairman, Professor S. W. Wooldridge, thanked Professor Rossby for a very memorable lecture. He himself preferred to contemplate the aesthetic beauty of the 500 millibar patterns even if it were eventually found necessary to bring them down to earth ! He was convinced that the secrets of the atmospheric circulation were to be found in the upper air in the same way that the explanation of surface forms was to be found below the surface.

T.H.K.

STORM WARNINGS FROM WAVES AND MICROSEISMS

By G. E. R. Deacon, F.R.S.

Royal Naval Scientific Service

Everyone who has to do with the sea and with ships knows something about waves, but it is remarkable how few attempts have been made to obtain precise information. Tribute must be paid to the work of the many eminent mathematicians and to the careful notes of seafarers of all times, but there is a wide gap between the mathematical theory and ships' observations and many questions about the generation and propagation of waves cannot be answered. The need for accurate information during the war did a good deal to stimulate research by modern physical methods and some notable advances have been made. The first was the development of recording apparatus, and except for the cost of laying submarine cable there is now no difficulty in recording waves by instruments laid in exposed positions a mile or more from the coast.

WAVES

It can be argued from hydrodynamical theory that wave-trains from different parts of the same storm, or from different storms, travel independently after they leave the storm area and that each storm should contribute its own wave-band to the mixture of waves recorded at any point in the path of the waves. If continuous wave-recordings are made at a time when the meteorological conditions are fairly simple it should be possible to differentiate between local waves and the swell from a distant storm. Attempts to separate such wave-bands were made by plotting histograms to show the frequency distribution of wave-periods in successive records, measuring the time-intervals from crest to crest on the records to obtain the wave-periods. Such attempts usually failed because the swell was obscured by shorter, higher waves, and it was soon realized that a sufficiently detailed separation of the wave-bands would require an analysing machine which measured the amplitude of every wave-length that might be present.

Such a machine was made (Barber and others 1946) and the comparison of wave-spectra from the north coast of Cornwall with the relevant meteorological charts of the Atlantic Ocean gave results in agreement with theory. The waves in a storm, and the swell leaving it, proved to be a mixture of all wave-lengths up to a maximum that depended on the greatest wind-strength, and by comparing the measured times at which these component wave-trains begin and cease to arrive at the Cornish coast with the times, estimated from meteorological charts, at which they began and ceased to be generated in a distant storm, it was shown that the component wave-trains travel independently with the theoretical velocities appropriate to their periods (Barber and Ursell 1948). These velocities are the "group-velocities" which in deep water are half the velocities at which single waves might be seen to travel for

a limited distance, the essential reason for the half value being that only half the wave-energy advances with the wave-form : the leading waves in a group gradually disappear as the group advances and new waves develop in the rear.

The group velocity is proportional to the wave-length and period, and expressed in knots its value in deep water is approximately 1½ times the wave-period in seconds. The short waves generated at the beginning of a storm are overtaken and outdistanced by the longer waves generated when the storm is at its height, and the separation between them increases with distance .The first indication of the swell in the wave-spectra at a distant observation point is the appearance of a narrow band of swell at the long-period end of the spectrum ; in successive spectra this band moves towards the short-period and becomes broader. Knowing the group velocities and the measured times at which the consecutive wave-periods cease to arrive, the distance of the generating area from the recording station can be calculated. With the help of such a technique bands of swell appearing in wave-spectra on the Cornish coast have been traced to storms in every part of the North Atlantic Ocean, and sometimes to storms in the high latitudes of the South Atlantic Ocean.

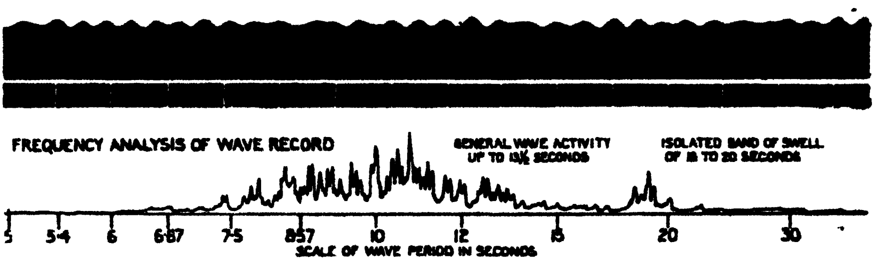


Fig. 1. A 5-minute sample of wave record. The wave spectrum obtained by submitting a full 20 minutes of this recording to frequency analysis is shown underneath.

On a number of occasions swell from a storm in 50°S. has persisted for 5 days on the Cornish coast, making its first appearance a week after it left the Southern Ocean.

The certainty, with which a particular wave-band can now be traced to its origin, allows coastal waves to be used to study the processes of wave-generation in distant storms. If the geostrophic wind-speed in the strongest part of the storm is U knots, the longest swell-period has been found to be approximately U/3 seconds, and using this empirical relation the longest recorded wave-period can be used to estimate the greatest wind speed in a distant storm ; in addition, the decrease in wave-period in successive spectra can be used to calculate the distance of the storm. The information will be several days old by the time the waves reach the recording station, and it can have no immediate application in the northern hemisphere where there are plenty of meteorological observations, but it may be useful in countries where the weather is influenced by storms from which no observations are obtained because they travel across empty stretches of ocean. The detection of the first long swell while it is not more than a few inches high may serve as a useful

warning of the high swell that will arrive within the next 24 hours, and such detection will usually be possible about 12 hours before the rising height of the swell among the local waves makes it perceptible to the eye. Such warning would be useful in an exposed anchorage and at an advanced base for flying-boats. Some indication must usually be obtained of the distance of the storm, because the first swell from a storm at a very great distance, like the Southern Ocean swell on the coast of Cornwall, is not followed by much higher swell

There are many outstanding problems the recording and analysing

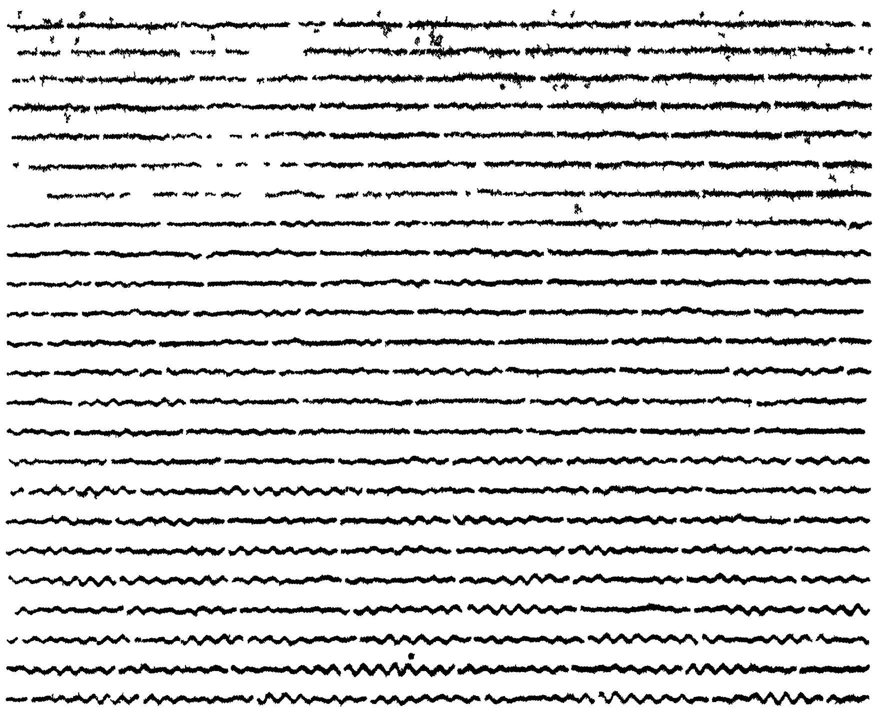
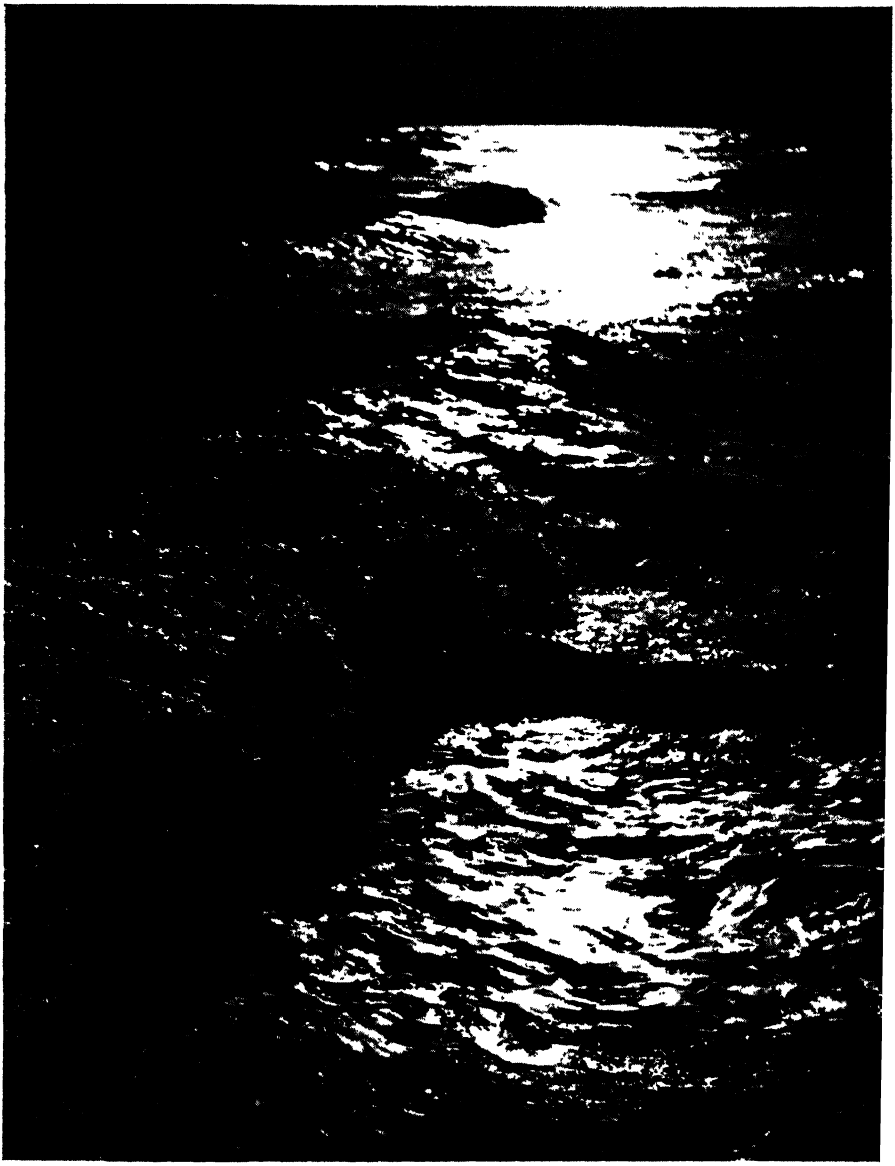


Fig. 2. A section of a typical seismogram showing approximately the first 8 minutes of each hour's trace on one day. The microseismic activity increased throughout the day. Each trace is interrupted at 1-minute intervals.

techniques are being simplified, the changes in swell as it passes through tidal streams and into shallow soundings are being studied, and progress is being made towards a method of measuring the direction of any swell-component that appears in the wave-spectrum.

MICROSEISMS

The new wave-studies have an important bearing on the possibility of using microseisms for detecting storms. It has been known for a long time that the 3 to 10 second oscillations which form a background, varying in amplitude from hour to hour and day to day, on seismograph records are related in some way to storms on the neighbouring ocean, and at some observat-

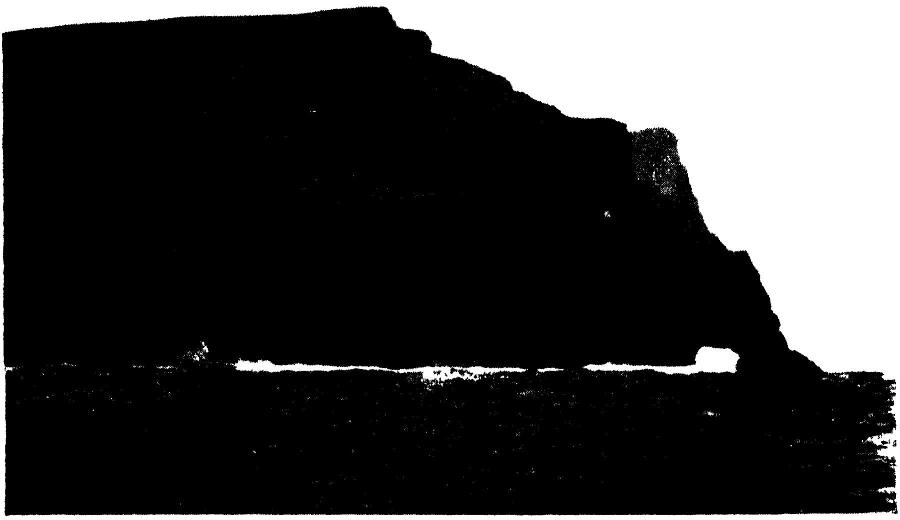


Across the restless sea at sunset

Photograph by] [*F. H. Crowe*

PLATE I

Approaching Foula in the motor boat which makes the 18 mile crossing from the Shetland mainland once a week (weather permitting !).



Foula from the North-West. These are some of the highest cliffs in Britain (see p. 93).

Photographs by [O. M. Ashford

PLATE II

ories an increase in the activity of the microseisms has been used as an indication of an approaching storm. Microseisms were first explained by the impact of waves against a steep, rocky coast ; but later, because the strongest microseisms in the Bay of Bengal were recorded several hours before the storm reached the coast, it had to be assumed (Banerji 1935) that they could be generated in deep water and transmitted along the sea bed. A thorough study of the

COMPARISON OF WAVE SPECTRA AT PERRANPORTH WITH THE SPECTRA OF MICROSEISMS RECORDED AT THE SAME TIME AT KEW

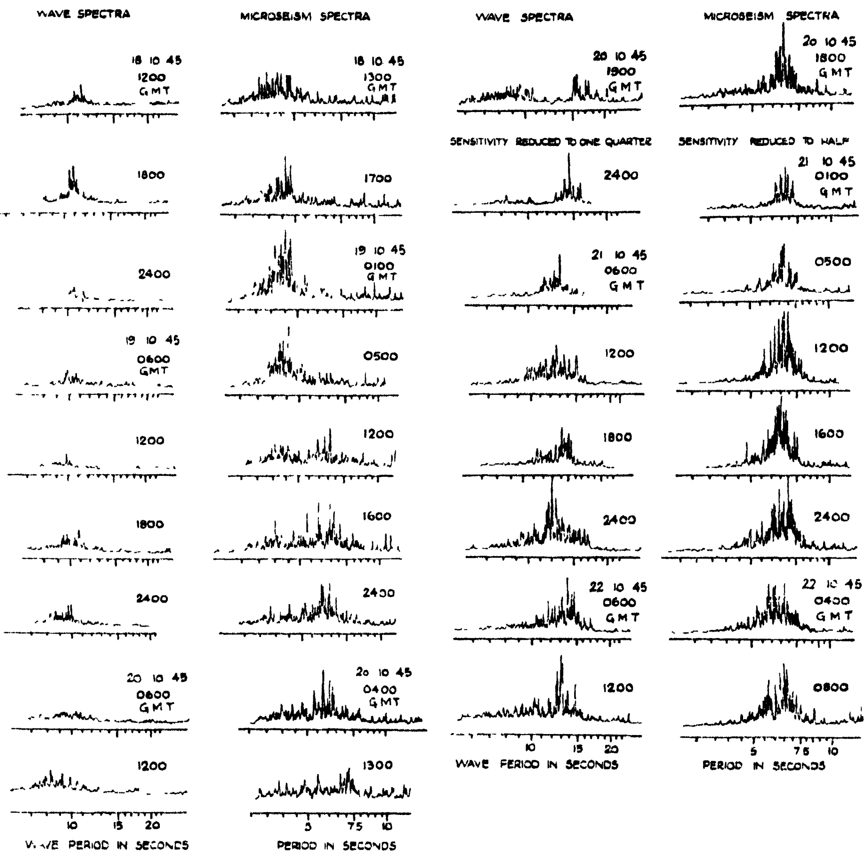


Fig. 3. Wave and microseism spectra obtained by submitting simultaneous wave records from the coast of Cornwall and microseismic records from Kew to frequency analysis (after Darbyshire).

microseisms produced by storms off the U.S.A. Atlantic coast (Ramirez 1940) showed that the microseisms could reach their peak and subside before the storm reached the coast. In this study earlier attempts to find the direction of the microseismic waves by measuring the time differences between the arrival of an identifiable wave at 3 stations a few miles apart, were improved, and the success that was achieved persuaded the Aerological Branch of the U.S. Navy to set up several 3-instrument stations for tracking hurricanes. The results have been summarized by Gilmore (1946) ; he concludes that the

dominant microseisms are produced while the storm is over deep water, and that the recordings afford a satisfactory method of tracking storms; a major hurricane could be detected up to 2,000 miles.

On the European side of the ocean the dominant microseisms seem to be produced in the coastal region. The fluctuations in microseismic activity at Kew are sufficiently similar to the fluctuations in wave-height on the Cornish coast to suggest that the passage of a cyclonic depression 1,000 miles west of the British Islands has no obvious effect on the microseismic activity at Kew. It was argued, however, that the problem might be similar to that of detecting low swell in the presence of high waves, and an attempt was made, using the technique developed for wave-analysis, to detect microseisms from a distant source in the presence of larger oscillations generated near the coast. The chief reason for being optimistic about such a possibility was that comparisons between waves and microseisms between Cornwall and Kew, and at Casablanca (Bernhard 1941), give a clear indication that the periods of the microseisms are closely linked to those of the waves.

The discovery of such a relationship has led to a new theory to explain the generation of microseisms. There has never been much doubt that the energy of microseisms is derived from the energy of a storm over the sea, and the mechanism by which the storm energy is transferred to the sea bed has generally been associated with the wave activity produced by the storm. The transfer of energy cannot, however, be brought about by an ordinary train of waves because the pressure fluctuations below a train of progressive waves decrease exponentially with depth becoming negligible at depths greater than a few wave-lengths, and also because the lengths of sea-waves are small compared with those of microseisms so that pressure changes below them would be very ineffective; this objection also holds in respect to the transfer of energy from the waves to a rocky coast.

Both objections are surmounted by the new theory which attributes the 3 to 10 second microseisms to the pressure fluctuations below standing waves which arise from interference between two wave-trains travelling in opposite directions (Longuet-Higgins 1948). It was shown by a French engineer (Miche 1944) that in standing waves there are second-order pressure variations of twice the wave-frequency which do not disappear at great depths; they are due to the changing vertical momentum of the water and produce fluctuations in the mean pressure on the sea bottom. Exact standing waves are not likely to occur, but it is only necessary that there should be groups of waves of the same period travelling in opposite directions and these can be expected to occur in a fast-moving depression, and in waves reflected from a steep coast. The amplitude of the compression waves at the bottom which depends on the product of the heights of the two wave-trains has been found to be sufficient to generate microseisms of the observed amplitude. It has also been found that the effect for a given wave-height may be greater in deep water than in shallow because of the resonance of the water layer.

The most striking result of the theory is that the microseismic periods

should be half the wave-periods ; and if trains of microseisms, like trains of sea-waves, behave independently, microseisms generated by waves of different periods should be distinguishable when the technique developed for wave-analysis is applied to a seismograph record. Analysis of some of the Kew records, made possible by the co-operation of the Director of Kew Observatory, has given a clear indication that such expectations can be realized. To quote one example (Darbyshire 1948), the wave spectra from the Cornish coast on October 18 and 19, 1945 (Fig. 3) showed a decaying band of swell with a mean period of 10 seconds, and the microseism spectra from Kew showed decaying microseismic activity with a mean period of 4·5 seconds. On the afternoon of October 19 a second band of microseismic activity with a mean period of 6·5 seconds began to appear in the microseism spectra, while waves of twice this period were to be found only in a storm centred 200 miles south of Greenland. The swell from this storm began to arrive on the coast of Cornwall on the afternoon of October 20 and its arrival was marked by a fresh outburst of microseismic activity.

The experience gained so far indicates that useful information about waves and storms can be obtained from seismograph records. If the storm is sufficiently close, and sufficiently intense to dominate the records, the 3-station technique used in U.S.A. will indicate its position. If, however, weak oscillations must be detected in the presence of larger oscillations from a nearer generating area, the wave-analysis technique will have to be used. The possibility of using microseisms to obtain information about distant storms is more attractive than a scheme to use swell recordings because they travel at approximately 2½ miles a second and, from a storm 1,000 miles away, arrive more than 24 hours before the swell. To overcome the remaining difficulties, and to devise a method of measuring the direction of a particular band of waves which appears in the spectrum, the studies of microseisms and waves, which are obviously closely related, must proceed together.

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STATISTICS AND METEOROLOGY*

By E. ROSINI

Rivista di Meteorologia Aeronautica, Rome : *Associazione*
Vol. VIII No. 1 Jan.-March, 1948, *pp.* 44-52. *Culturale Aeronautica*

This interesting and stimulating article is really an appeal for a wider application of statistical method in meteorology. The author considers that the problem of method, now held to be of vital importance in the different sciences, is largely neglected in meteorology.

The different sciences fall rather easily into two groups, those like physics and chemistry which, at least as far as macroscopic phenomena are concerned, are governed by " exact " laws—inherently necessary ; others, like biology and economics, governed by " statistical " laws or laws of probability. Progress in the sciences of this latter class must obviously be a slow and arduous process requiring different techniques than are employed in the " physical " sciences. The author's contention is that meteorology belongs to the class of sciences governed by statistical laws ; that this fact is inadequately recognised by many meteorologists who would prefer to see meteorology taking a place alongside physics in the class of exact sciences. This dream must be abandoned and meteorologists must be prepared to tread the arduous and painful path towards the establishment of " statistical " laws.

A division has arisen among meteorologists. On the one hand meteorologists with a theoretical bias have tried to identify meteorology with the physics of the air and are now occupied with concepts which, though they may emphasise some aspects of reality, are nevertheless inadequate in producing a representation of real value in practice. The author quotes the most noteworthy example—the Bjerknes theory—and remarks that, while acknowledging its great theoretical value, it must be admitted that its practical forecasting value is of less importance than the psychological suggestion and incentive to which it has given rise. It has provided the forecaster with a homogeneous and efficient symbolism permitting a greater use of intuition and personal experience to which the improved standard of forecasting must be attributed. On the other hand, meteorologists of practical temperament have perceived the urgency of providing an efficient basis of observational data before embarking on theoretical abstraction but have tended to fall into a sterile empiricism. Many of these have used statistical methods but, dominated by a species of inferiority complex, have restricted their efforts to such rudimentary statistical exercises as finding frequencies, diurnal variations, etc., that in reality are of use for particular purposes but, for the most part, do not contribute to the understanding of meteorological phenomena

Meteorology must be something more than the physics of the air inasmuch as its subject matter is not only the atmospheric structure but also the prediction of changes and their interpretation in terms of weather. It is usually

* Review

divided into dynamical meteorology and synoptic meteorology. Dynamical meteorology, by which is understood the statics, kinematics, dynamics and thermodynamics of the atmosphere is the mathematical or physical study of typical elements abstracted from the field of real experience. The distinction between this branch of meteorology and the physics of the air is often slight. Synoptic meteorology, on the other hand, is the study of weather phenomena in their distribution over a wide area, with the aim of discovering causes and hence predicting future development. On the theoretical side, this study seeks to synthesize the results of dynamical meteorology ; on the practical side, it seeks to apply the theory to real situations. For example, the conditions for the existence of a surface of discontinuity, the determination of its inclination and its movement, form part of dynamical meteorology. The Norwegian theory of depressions and several mathematical attempts at forecasting belong to the theory of synoptic meteorology ; the practical aspect consists of the routine synoptic work of a meteorological service. It is here that the weak spot is to be found. If dynamical meteorology and theoretical synoptic meteorology were valid and satisfactory bases, the forecaster, once equipped with a certain standard of theoretical knowledge, would find it easy to interpret the synoptic chart and compile his forecast. This is not so in practice where the forecaster often has recourse to auxiliary aids, as e.g., "analogues". Forecasters acquire confidence not so much from the amount of theory they know but from the direct experience that they have been able to acquire and from intuition. The author's contention is that statistical methods can be used to further not only meteorological knowledge but also forecasting techniques. He defines "statistical meteorology" as the study and representation of meteorological changes by means of statistical methods of investigation with the aim of discovering statistical laws governing the mechanism of these changes and of deriving a method of forecasting the probabilities of likely developments. Examples of work in statistical meteorology cited by the author include the trajectories of barometric minima (Van Bebber), isobaric types (Schiaparelli, De Marchi, Eredia), classification of air masses (Schinze), forecasting by correlations (Schumann). Although not specifically mentioned, the work of G. T. Walker on seasonal forecasting in India must constitute one of the finest examples.

The author then gives a brief historical survey of developments in statistics and illustrates his belief that up to the present the application of statistics to meteorology has been crude and rudimentary and that more elaborate methods are necessary.

To some extent, the argument throughout the paper is rather enthusiastically overstated, for statistical methods of investigation in meteorology are gradually being introduced and are making headway. But that arguments such as these are still necessary is apparent to all who take even a cursory interest in either dynamic or synoptic meteorology.

T.H.K.

TURBULENCE IN CLOUD AND CLEAR AIR

The fourth of the present series of meteorological office discussions held at the Imperial College on January 31, 1949, was opened by Mr. J. K. Bannon. He began by explaining that his contribution would be limited to turbulence in clear air at heights above 20,000 feet. For some years reports had been coming in of bumpiness experienced by pilots flying in fine weather in the upper troposphere and even in the lower stratosphere. Aircraft designers were vitally interested in the size of the bumps which aircraft might experience, as it affected the structural design of the aircraft and the comfort of the passengers. Very few data were available about these phenomena ; the main sources were the Aldergrove Prata Flight, special flights made at the Royal Aircraft Establishment, the Meteorological Research Flight, the Mosquito flights made by British European Airways and reports obtained by interrogation of R.A.F. pilots.

Bumps were usually expressed in terms of the acceleration experienced ; an acceleration of $0{\cdot}1g$ (g is the acceleration due to gravity) was perceptible, $0.25g$ was uncomfortable and would give rise to complaints from passengers, $0.5g$ was very unpleasant and would lead to letters of complaint while if $1.0g$ were experienced, passengers would become airborne in more senses than one ! The maximum bump actually recorded in clear air above 20,000 feet was $0.7g$, as compared with $1{\cdot}5g$ found in cumulo-nimbus clouds. Some pilots had reported that these clear-air bumps were different from convection bumps in that they tended to be periodic in character, several bumps being felt sometimes at regular intervals. Bumps had been noted in Western Europe above every type of surface weather and at all heights up to at least 42,000 feet. Some of the investigators had found a marked maximum of frequency at the tropopause and at other checks in the temperature lapse rate.

Mr. Bannon said that attempts had been made to correlate bumps with the vertical wind shear, with the lapse rate, with the Richardson number and with the horizontal wind shear ; only the last of these had yielded positive results. Forecasters might therefore expect to find bumpy conditions where there was a large horizontal wind shear, such as in the neighbourhood of fronts and near the edge of the jet stream (see *Weather* Nov. 1948, p. 339). It was difficult to understand why there should be no correlation between bumps and vertical wind shear, but the answer was probably that the significant changes of wind with height were smoothed out by the pressure method of averaging the wind observations over an interval of 3,000-4,000 feet. Another mystery was why these bumps should be so frequent in such stable conditions as would be expected near temperature inversions at the tropopause and elsewhere.

FLYING IN CUMULONIMBUS

Mr. R. F. Jones dealt with turbulence in cumulus and cumulo-nimbus clouds. Attempts were being made to find if there were any connection between the echoes from clouds observed with radar sets and regions of bumpi-

ness. Echoes obtained with two 10cm. radar sets installed at East Hill (three miles from Dunstable) were photographed and subsequently compared with records of acceleration made in a Spitfire sent up from Farnborough. The aircraft was controlled by R/T from East Hill ; the pilot would be told to fly towards or away from the station, i.e., along the radar beam, at various heights, sometimes across the areas from which the most marked echoes were being received and sometimes in between the echoes. Mr. Jones paid a tribute to the pilots of the Aero Flight at Farnborough who were taking part in this dangerous work ; they now modestly maintained that so long as they were prepared for bumps and kept their heads there was littlereal danger.

Results so far were only tentative but very promising : 26 sorties had been made which had involved 136 flights in cloud over a total distance of 700 miles. A statistical analysis had showed that there was a marked correlation between the maximum upward gust and the vertical extent of the radar echo above the freezing level. It had been reported from America that the greatest turbulence was found near the freezing level, but in these flights no regions of either maximum or minimum bumpiness had been detected.

Detailed analyses of some of the flights had shown that the largest bumps were encountered on entering or leaving the edges of the echoes. As the strength of the echo was proportional to the sixth power of the diameter of the water drop, the edge of the echo was the place where an increase in drop diameter occurred or where there was a large increase in the number of drops. It had also been found that calm patches, sometimes several thousand yards in extent, occurred in the centres of echoes. An echo which was developing was generally from a region of great turbulence, while a dying echo was associated with calmer conditions.

Mr. Jones concluded with a glimpse of the future. The investigations were to be extended to other types of cloud and experiments would be made to find out if it were wise to attempt to guide an aircraft down a lane between the echoes—it was conceivable that an aircraft could be steered over a cold front without encountering any turbulence.

DISCUSSION

Dr. Hislop of British European Airways referred to a statement by Mr. Bannon that the only waves which could be sustained at the tropopause by dynamical considerations would have wavelengths which were too long to cause bumpiness ; he wondered if the waves could break like ocean waves and if the eddies were associated with the edges. Mr. Morris of the Royal Aircraft Establishment said that the greatest hazard found in cumulo-nimbus clouds was hail. Two of their aircraft engaged in these special investigations had been damaged by hail. They had not found a peak in the bumpiness at the tropopause ; in recent flights many bumps had been felt in the stratosphere. Dr. A. H. R. Goldie thought that there must be a correlation between bumpiness and vertical wind shear as regions of great horizontal wind shear must also be regions of considerable vertical wind shear.

Dr. R. Frith of the Meteorological Research Flight pointed out that any particular aircraft flying at a given speed would only be affected by eddies of a particular size ; other eddies might well be there and pass undetected. On one occasion he had found a belt of bumpy air in an otherwise calm region which persisted for at least two hours and moved slightly relative to the surrounding air during this period

Dr. J. M. Stagg wondered if jet streams and turbulence were examples of the same family of phenomena , the jets might be regarded as the fathers and the eddies the children. If so, it might be most profitable to tackle the most accessible member of the family first, i.e. the jet stream, in the hope that it would throw light on the other members. In this particular family, the man might well prove to be the father of the child !

In replying to a question raised by Mr. E. Gold, Mr. Bannon said that topography of the earth's surface appeared to have some effect. In conclusion Sir Nelson Johnson said that it was hoped to study eddies by observing the behaviour of smoke trails. He thought that the most fundamental problem was to find the source of the energy needed to maintain the eddies. The discussion had shown that the question of turbulence in clouds and clear air was of great interest to many different people and that our present knowledge of the whole subject was still extremely limited.

O.M.A.

A NEW GEOPHYSICAL JOURNAL

The Swedish Geophysical Society has announced that it is publishing a new quarterly journal of geophysics, *Tellus*, edited by C. G. Rossby. The journal is to be a " medium for the publication of original contributions, survey articles and discussions in the field of the geophysical sciences. " The Society hopes thereby " to contribute to international cooperation between geophysicists and to provide an international forum for discussions and exchange of imformation. " All contributions will be in English, French or German. Judging by an advance copy of the first number, there is likely to be much of interest to meteorologists, as will be seen from the list of contents, which includes :—" The problem of artificial control of rainfall on the globe " by Tor Bergeron (who has been awarded the Symons Medal this year) ; " On the origin and structure of high-level cyclones south of the maximum westerlies" by E. Palmén ; " Dispersion of planetary waves in a barotropic atmosphere " by C.-G. Rossby. The subscription is 30/- per annum ; all business correspondence should be addressed to the office of the editor, Fridhemsgatan 9, Stockholm, Sweden. This new venture should fill a gap in international scientific periodicals and we take this opportunity of wishing Professor Rossby and his colleagues every success.

ROYAL METEOROLOGICAL SOCIETY NEWS

The fourth popular lecture of the season was held on Thursday, February 10, in the Science Museum Lecture Theatre. Sir Nelson Johnson spoke on "Some international aspects of meteorology", a subject on which both he and the Chairman, Mr. E. Gold, are rightly acknowledged as leading authorities. Our report is being held over until the May issue, which is to be a special international number. Owing to pressure of space, we are forced to postpone until April the report of Dr. G. M. B. Dobson's Presidential Address.

The Council and those Members who are able to attend the meetings at the Society's rooms are indebted to Mr. N. R. Hagen of the U.S. Embassy, Mr. M. J. Oretzki of Winnipeg and Capt. B. V. Siegel of Berkeley, California, for generous gifts of evaporated milk and sugar for use in the tea provided prior to the meetings.

LARGE-SCALE VERTICAL MOTION

Recent discussions have been marked by a feeling of excitement at the rapid progress now being made in so many branches of meteorology, and the one on "Large-scale vertical motion in the atmosphere" held in the Society's rooms on February 16 was no exception Mr. J. K. Bannon opened the discussion by reminding his audience of the important role of vertical motion and of the need for information on its magnitude and distribution. He had developed an indirect method of estimating vertical motion from the rate of rainfall which gave useful results except in cases of instability and orographic rain : vertical speeds up to 20cm./sec. had been found.

Mr J. S. Sawyer then outlined the thermodynamic approach developed by R. C. Graham, which involved the use of trajectories on constant pressure charts, and went on to give details of his own method, which was based on the equation of continuity and the vorticity equation ; it gave results in agreement with synoptic models and with those obtained from Mr. Bannon's method.

The work being done in the Meteorological Department of the Imperial College was then described in his usual lucid manner by Professor P. A. Sheppard. The horizontal mass divergence at various levels was derived from the upper wind observations made by radar at stations in the British Isles—the finest network in the world Computations were made for each triangle of stations by a straightforward objective technique ; a complete computation could be completed in about 30 minutes. The work was still in its early stages but some very interesting and suggestive results had been obtained both by statistical analysis of the frequency distributions of vertical motions with height for different months and by detailed examinations of individual situations. Vertical speeds of between 25 cm./sec. upwards and 15 cm /sec. downwards had been found.

Dr. R. S. Sutcliffe expressed a widely felt view when he remarked that at long last meteorologists were "getting somewhere" in this most absorbing problem. As there could never be a close network of upper wind stations over the whole world, he thought that the British and American observations should be used to compute a set of typical results in representative synoptic situations which could then be applied elsewhere.

In thanking the various speakers, Sir Robert Watson-Watt said that he had found the "build up" of evidence most fascinating and he was sure that Sir Napier Shaw, who employed similar lines of reasoning whenever possible, would have been delighted to have heard of such great progress.

MIDLAND CENTRE

Nearly sixty Fellows and friends attended a meeting of the Midland Centre on January 25, when Dr. J. Glasspoole spoke on "The development of our knowledge of rainfall over the British Isles during the last 30 years". The main progress had been in mapping rainfall, as initiated by Dr. H. R. Mill, and in securing satisfactory exposures for rain-gauges, which had been of special interest to Mr. Carle Salter, who died in 1932. The maps showing the distribution of average rainfall, planned by Mill and Salter, had been completed recently, and further maps on a reduced scale were being published by the Ordnance Survey. Reference was also made to the preparation of other maps covering more extended periods. From diagrams expressing the rainfall at individual stations for consecutive years as a percentage of the average annual rainfall, Dr. Glasspoole showed that extreme values obtained in this way at different stations were similar. He also demonstrated the sequence of rainfall since 1868 by diagrams showing the trends of the winter and summer rains separately.

CANADIAN BRANCH

The Annual Meeting was held in Toronto on January 14, and the following members were elected as the Executive Committee for 1949:—

President	P. D. McTaggart-Cowan
Vice-President	D. C. Archibald
Secretary	F. W. Benum
Treasurer	F. G. Millar
Councillors at Large	G. L. Pincock, Vancouver
	G. W. Robertson, Edmonton
	R. A. Hornstein, Halifax
	Prof. F. K. Hare, Montreal
	S. J. Buckler, Winnipeg

Correspondence in Canada should be addressed to F. W. Benum, 315, Bloor Street West, Toronto, Ontario.

FORTHCOMING MEETINGS

On March 16, at 5 p.m. in the Society's rooms, there will be a discussion on "Meteorology in agriculture"; the opening speakers will be H. L. Penman, M.Sc., Ph.D., F.Inst P., and R. W. Gloyne, B.Sc.

On April 6, at 6 p.m. in the Lecture Theatre of the Science Museum, Exhibition Road, South Kensington, Dr. G. M. B. Dobson will give the next of the series of popular lectures—"Some solar and terrestrial relationships" The Chair will be taken by Professor Brunt. All interested are cordially invited.

C. T R. WILSON

A telegram of congratulation was sent on behalf of the Society to Professor C. T. R. Wilson, F.R.S., on the occasion of his 80th birthday on February 14. We would like to extend to Professor Wilson from all readers of *Weather* very best wishes for many years of happiness and fruitful research.

GEORGE AUBOURNE CLARKE

We regret to announce the death of Mr. G. A. Clarke, so well known to all meteorologists for his wonderful cloud photographs. Mr. Clarke's life and work were described in the article by C. A. Wood in *Weather*, June 1948. Readers will join us in expressing our deepest sympathy to Mrs. Clarke.

MY BY-WAYS IN METEOROLOGY

By C. E. P. Brooks, D.Sc.

My first love was geology ; after I joined the Meteorological Office geology was mated with meteorology, and the offspring was naturally palaeoclimatology, or the study of climatic changes. The plan was simple—first to collect as many facts as possible, and then to try to explain them. The collection of facts, though laborious, is straightforward, and in 1922 I summarized the existing knowledge in my first book, *The Evolution of Climate*. As a book it was immature, but it was redeemed by my insistence that, owing to interactions between different regions, great climatic changes such as glaciations must be—geologically speaking—contemporaneous in all parts of the world.

Theory was more difficult. Even at that time at least fifty different explanations of climatic changes had been put forward—the number has grown considerably since—and all these had to be examined. There were variations of solar radiation, changes in the earth's orbit, the composition of the atmosphere (especially the amount of carbon dioxide), volcanic activity, land and sea distribution, mountain building, ocean currents, atmospheric circulation and, finally, movements of the poles and continental drift. Present-day climatology is sufficiently complicated, but at least it has a solid basis in the solar constant, the fixed seasons and a stable geography ; in palaeoclimatology all these have to be treated as variables and the effect of changing them worked out.

The result of my investigations was a growing belief in two main principles: first that all the major changes of climate, lasting millions of years, could be explained solely by " geographical " causes—land and sea distribution, relief, ocean currents, volcanic activity, etc., leaving only fluctuations of, say, 100,000 years and less for variations of solar radiation, eccentricity and similar factors ; and secondly, that there is a great gulf between " glacial " climates such as Ice Ages (we are still living in an Ice Age !) and the mild or " non-glacial " climates which have made up most of geological time.

These two theses were gradually developed in a series of papers published in the *Quarterly Journal*, and are set out in greater detail in *Climate through the Ages* (1926). A merely qualitative exposition would have been of little value ; a quantitative check was essential. This was obtained in three stages :

1. Numerical evaluations of the effects of the various geographical factors as seen in operation to-day.
2. Estimates of the magnitudes of the geographical factors in the geological ages, and of the temperatures of middle latitudes deduced from fossil remains.
3. Quantitative evaluations of the effects of the geographical factors from the geological evidence alone, and their comparison with the climatological estimates.

The results showed surprisingly good agreement, and confirmed me in my conclusions. In the second edition of *Climate through the Ages*, to be published

early this year, I have seen no reason to modify them.

Climatic changes during the historical period are in a different category, since they are much smaller, and are obviously not due to geographical causes. In studying them, I started from the other end, partly by trying to unravel the transient effects of fluctuations of solar activity, Arctic ice, volcanic eruptions and similar factors on the atmospheric circulation, and partly by a detailed examination of notable climatic vagaries during the period of instrumental observations. The former were published by the Meteorological Office as *Geophysical Memoirs* or in the *Meteorological Magazine*, the latter mainly in the *Quarterly Journal of the Royal Meteorological Society*. These investigations have brought to light some interesting effects, but so far have not produced any coherent picture.

The study of climatic changes was of course only a hobby ; my real work was in the Library and Climatology Branch of the Meteorological Office. About the Library there is not much to say ; an efficient library is mainly a matter of patient, accurate cataloguing, a desire to be of service, and a memory for books, in that order. Subject cataloguing is especially important, but in a rapidly developing science such as meteorology a subject classification soon becomes out of date. That in use in 1928 had been designed in 1895, when upper-air investigation was in its infancy while fronts and air-mass analysis were still to come. After a campaign lasting seven years, with the help of Dr. Th. Hesselberg I succeeded in designing a completely new classification for meteorology within the framework of the Universal Decimal Classification, and in obtaining its acceptance in 1935 by the International Meteorological Conference at Warsaw. This classification was adopted in the Libraries and Bibliographies of the Meteorological Office and Royal Meteorological Society in January 1936. A large-scale revision was made by a Sub-Commission of the International Commission for Bibliography in 1947 and is now awaiting adoption.

Finally comes Climatology, a vast untidy subject which is generally rather dull in spite of occasional high lights, but one which is of great importance in industry, commerce and medicine. The climatic data which pour into the Meteorological Office from all over the world need to be put together before they can be used, and for several years I used up a lot of my time and the Society's paper in climatic summaries. In the last few years the emphasis has shifted to "applied climatology" ; enquirers no longer want just tables of mean and extreme values, they want to know how the data affect their own particular problem. A beginning was made with the effect of climate on the deterioration of materials (*Quarterly Journal*, 1946, p. 87), but there is still room for a great deal more work in this field.

The past few years have also seen a great development of upper-air climatology, particularly in the service of aviation. A problem of especial urgency was the charting of upper winds. Owing to scarcity of data, and indeed their complete absence over large parts of the world, a direct approach was not possible. Methods of vector statistics were worked out, and were

applied in a series of bold generalisations, by a team led by Mr. C. S. Durst and myself, with Mr. J. S. Sawyer, Miss N. Carruthers and Mr. D. Dewar. A preliminary paper was issued in 1946 (*Quarterly Journal* p. 55) and the publication of an account of the final results is now under consideration.

The recent developments of climatology, and a number of problems which arose during the war, called for modern statistical methods, and even the development of new techniques of analysis. In collaboration with Miss N. Carruthers, in 1944 I began a survey of the whole field of the application of statistics to meteorology, and we are now engaged on the preparation of a complete handbook of the subject.

It will be seen that, though I have retired from active administration, I am not likely to run out of occupation. Thanks to the kindness of Sir Nelson Johnson, I am able to remain for the time being on the staff of the Meteorological Office to complete some of my official work, but I am also looking forward to a good deal of " homework " in climatology and the study of past climates.

Dr. C. E. P. BROOKS, I.S.O.: CLIMATOLOGIST

By N. Carruthers

My clearest impression of Dr. Brooks is of him as he is now: tall, slim, white-haired, gentle and friendly in manner, but possessed of more than ordinary vigour both mentally and physically. Other impressions, comprising many of the details of this biographical sketch, have been gleaned in conversation with him

Charles Ernest Pelham Brooks was born in Central London on November 10, 1888. His whole life has been characterized by a love of reasoning and a thirst for knowledge From an early age he read voraciously. His reading included much history, nearly all Darwin's books and a number of volumes of the *Popular Educator*, one of the sources of the curious bits of information he still unearths at times from the recesses of his memory. In 1903 he won a scholarship to University College School where he studied for the Intermediate B.Sc. in Economics His was the commercial side, his family envisaging him as a future " business man ", and there was little opportunity for him to develop his mathematical ability. However, he was permitted to sit for the examination—a problem paper—on which the school's annual Mathematics Prize was awarded. To the great dismay both of the masters and of the recognized school mathematician, Charles Brooks, a boy with little mathematical training, carried off the prize !

Much of Dr. Brooks' brilliance is due to his ability to visualize. He has often said that, once he is able to picture a thing, he can understand and explain it. This power of visualization may be responsible for his clarity of description which, in his popular writings, enables his readers to see, without effort, the thing he is describing: *The Weather* includes a delightful explanation of changes of pressure with height and, in reading *Climate through the Ages*, one becomes personally acquainted with the small expanding ice-sheet,

On leaving school, he had the choice of two posts. One was in a bank at twenty-five shillings per week rising, after six months, to thirty shillings. (This was in 1907 !) There were prospects, too, of a transfer to Switzerland. The other post was in the Meteorological Office at eighteen shillings and sixpence with, at that time, no prospects whatever. To the surprise of his family, he chose the second post. Although he had found economics interesting, Brooks did not want to play a part in the World of Commerce ; his *métier* was going to be geology, and the shorter hours in the Meteorological Office held promise of more free time for study.

Shortly after joining the Meteorological Office, Brooks set himself to work for a degree. He attended evening classes in geology and zoology and, in a trial canter for the Intermediate examination, won the King's Prize in Zoology; mathematics (pure and applied) he learnt for himself from the necessary text-books. After only eighteen months' evening work on four almost new subjects, he passed Inter. Science in 1910. Two years later, he achieved his degree--honours geology with subsidiary zoology.

In spite of this intensive study in the evenings, Dr. Brooks had already begun to take a keen interest in meteorology. While still in a junior position in the Meteorological Office, he attended its Monday evening discussions : and, a year after taking his degree, he became a Fellow of the Royal Meteorological Society. He read his first paper, *The Meteorology of an ice-sheet*, before the Society in December 1913. During the next twenty years he contributed, to the *Quarterly Journal* alone, no less than fifty original papers as well as reviews, translations and commentaries on the works of other authors. The Buchan Prize –awarded every second year to the meteorologist who, in the preceding five years, has made contributions to the *Quarterly Journal* of outstanding value– went to Dr. Brooks in 1931.

By this time, he had achieved M.Sc. Geology (1916) and, in 1926, his final qualification of Doctor of Science. This was in meteorology, the particular paper on which it was awarded being " The variations of pressure from month to month in the region of the British Isles "—the first of a series of attacks on the problem of seasonal forecasting.

The amazing vigour characteristic of Dr. Brooks' work and study is to be found also in his other activities. In his early years at the Meteorological Office, when he was working for his first degree, he used often to put in an hour's tennis before going off to the office in the morning ; as recently as the winter of 1942-3, during the time that some of the branches of the Office were at Stonehouse, he would regale shivering assistants with an account of his cold morning bath and seven-mile cycle ride from Chalford. Tennis, cycling, bridge, chess and photography are among the recreations which have received Dr. Brooks' concentrated attention. He played first board in the Air Ministry chess team from its beginning until shortly before the outbreak of war, and also played in a very successful Meteorological Office team during the " exile " in Stonehouse.

His marriage to Miss Dora Buckeridge in 1916 was the culmination of the first romance within the Meteorological Office. Before the 1914-18 war, young men and women employees were not allowed to see one another during office hours ; but Brooks and Miss Buckeridge had travelled to work together and had oft-times strolled through Kensington Gardens before the office was open at nine-o'clock. Mrs. Brooks, with her sense of humour and her helpful considerateness, has contributed much to her husband's successes, apart from her willingness to perform occasional computations or madly rushed jobs of typing. Their only son was born in 1926.

Dr. Brooks likes doing things with his hands. He remarks sometimes that he would have been no less happy as a carpenter or cabinet maker than as a climatologist. His house at Ferring bears varied evidences of his ingenuity, and these are not so very " Heath Robinson " either.

Knowing his aptitude for research, his mathematical ability (albeit almost untrained), his love for the open air and his delight in simple things, one is not surprised to find him a poet. In his schooldays, his verses showed promise ; and members of the Meteorological Office will probably remember his contributions to the " Cyclone " of the 1914-18 war and his several more recent lyrics during evacuation in Gloucestershire 1939-45. He has a very real love of poetry, and I think the mysticism of it appeals to him a much as the lilting rhythms which he professes to like so much.

Dr. Brooks, to use his own words, might have been almost anything -- except a musician or an artist. This very versatility may be responsible for the keenness and freshness of his outlook which causes him to tackle each new problem with dogged persistence—at least until it ceases to require thought and ingenuity. He may perhaps be forgiven for showing, at times, impatience with the anticlimax of niggling details required to round off the investigation. He is never at loss to provide, if not a solution, at least a definite line of attack for any problem referred to him. The late Sir Napier Shaw once remarked of Brooks that, even if the original aim of an investigation undertaken by him were not fulfilled, it always resulted in something interesting. Dr. Brooks is ever full of ideas. His brain is so swift moving that it endows its owner with an appearance of leisureliness. Indeed, he often manages to by-pass logical steps of argument and hit upon an answer with a directness that is uncanny. As may well be imagined, this trait was a stumbling block to him at school, for there inability to give reasons was regarded with suspicion.

Although Dr. Brooks has retired officially from the Meteorological Office, he has not retired from meteorological work and we hope to see more of him at the Society than in recent years when attendance at meetings necessitated a journey from Stonehouse or from Harrow. His associations with the Royal Meteorological Society are of long standing and he has played an active part in its affairs. He was an Honorary Secretary from 1927 to 1931, vice-president in 1932 and 1933, and a councillor during the periods 1916-21, 1923-26 and 1936-38. Up to a year ago he was also the Society's librarian ; in 1936 he

introduced into the library the new (universal decimal) classification for meteorological literature approved by an International Commission (Warsaw 1935) of which he was a member.

The organization of the library of the Meteorological Office, in its present form, was initially the work of Dr. Brooks. For most of his sojourn in the Office, he was in close contact with the library. He joined its staff on first joining the Office, took charge of it in 1913 and, apart from a few years during the 1914-18 war, it was included under his supervision until his retirement. His other main charge was Overseas Climatology, and to him fell the task of planning *Réseau Mondial*. This is an annual publication giving monthly values of the main meteorological elements for stations in a " world network ". In 1938, the Library and Overseas Climatology were joined by British Climatology ; more recently, the new sections dealing with upper air statistics and with meteorology in agriculture came into being under Dr. Brooks' jurisdiction. Last June, as Assistant Director (Climatology), Dr. Brooks was made a companion of the Imperial Service Order in recognition of his work in the Meteorological Office.

In addition to his work within the Meteorological Office mention must also be made of his activities in connection with the International Meteorological Organization : at Wiesbaden in 1934, Warsaw in 1935 and Toronto in 1947, the Commissions on which he served being concerned with Bibliography, Climatology, Hydrology and Agricultural Meteorology.

Working with Dr. Brooks is a real education. One gains from him confidence, simplicity and the art of co-operation ; and he is not slow to encourage or to give credit for the least suspicion of an idea : his assistants cease to be mere assistants and become collaborators. Work would be pure joy—if only one could keep pace with him.

THE METEOROLOGICAL ASSOCIATION

The Annual General Meeting of the Meteorological Association will be held at Imperial College Refectory, South Kensington, at 6.0 p.m. on Friday, April 1, and will be followed by a Supper at 7.30 p.m. Tickets for the latter, price 5/-, can be obtained from the Hon. Treasurer, W. P. Osmond, 238 Sheen Lane, East Sheen, London, S.W.14. Application should be made before March 21. Readers are reminded that membership is open by election to any person who is, or has been, a full-time practising meteorologist, whether as a member of the Meteorological Office staff or of H.M. Forces.

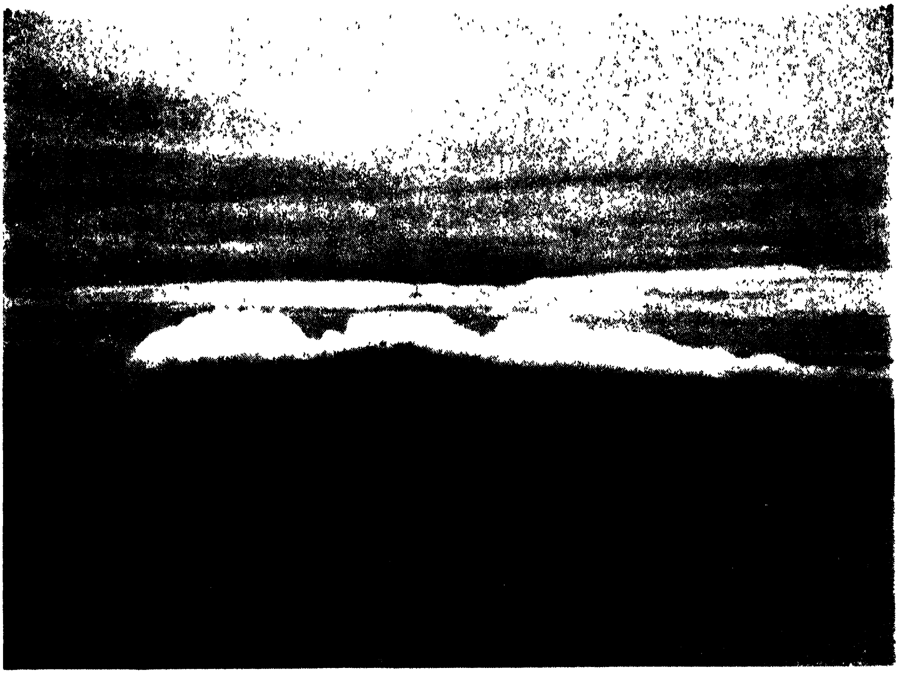
R.A.F.V.R METEOROLOGICAL SECTION

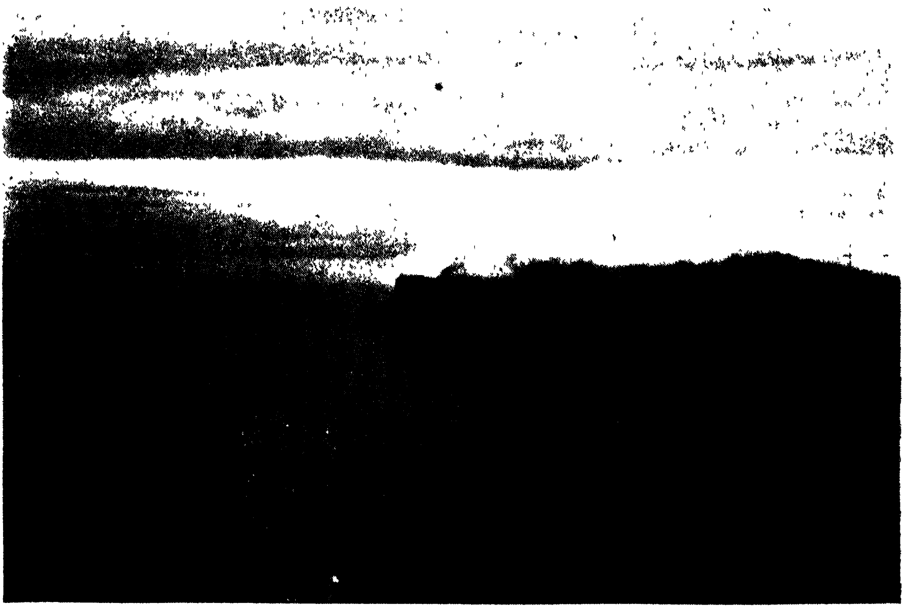
Meteorologists and those interested in the subject may now join the Royal Air Force Volunteer Reserve for spare-time service and training. Officers, airmen and airwomen with meteorological experience in the war of 1939-45 who are not now in the Meteorological Office are especially wanted. Further details are available at any R.A.F. Recruiting Centre or from the Air Ministry (M.O 10), Victory House, Kingsway, London, W.C.2.

C. E. P Brooks.

Photograph by] [*M. Marten*]

PLATE III





Orographic cloud over Foula (1,373 feet)

TRADITIONS OF FOULA FISHERMEN

During the winter months, it is not uncommon to find a short paragraph in the daily press describing how " Britain's loneliest inhabited isle " has been isolated by Atlantic storms for six weeks or more. Only two and a half miles wide and three and a half miles long, Foula lies about fifteen miles westward from the mainland of Shetland ; its western flank contains some of the finest cliff scenery in the British Isles. It is not surprising that the inhabitants, brought up in such surroundings, have become intimate with the ways of the sea. Before the advent of radio weather forecasts, the old men used to give forecasts to fishing expeditions based on the appearance of the sea. They probably had an inkling of the ideas set out in Dr. Deacon's article on page 74. In the opinion of Dr. A. H. S. Holbourn, one of the lairds of the island, these predictions were not always reliable. He writes : " The art of predicting the weather from the swell has pretty well died out. A much more reliable method is by means of the tides—the Foula people are still ahead of the Admiralty in this. If the tide runs to the south for a longer time than it should, if it is stronger, and the north tide correspondingly weaker, there will be a gale from the S. or SW. The reason is that under a cyclone the air pressure is below normal, hence the mean level of the sea is higher. In equilibrium, one foot rise of sea would correspond to about one inch fall of the barometer. Now the mid-ocean tide is only a matter of two feet or so and the rise due to a falling barometer is therefore comparable in magnitude with the normal rise of the tide. The hump of sea under the cyclone must have come from somewhere, hence there is a tendency for the tide to flow towards the centre of the cyclone. The friction of the wind on the water also has an effect ".

There is also a Shetland tradition that before the days of the magnetic compass the fishermen, who used to go almost out of sight of land to fish in their sixerns, or six-oared boats, could find their way back to harbour in stormy or misty weather when they could not see the land by the set of what they called the "moder dye". Mr. T. M. Y. Manson, the Editor of the *Shetland News*, describes this as " an under-surface movement constantly setting towards the land no matter what direction the wind and surface waves take, nor how fierce the storm. The practised eye could always discern the set of the moder dye, the ' mother wave ', across the surface undulations. Once the compass came into use, the men lost this accomplishment, and to-day it is just known about and no more ". Referring to sensing distant storms he says : " Breaking surf and waves on shore in apparently calm weather can tell anybody that there is something doing 'out by', but how far off is another question. Fishing disasters in Shetland in summer, such as the July 1881 disaster, when 58 men were lost for want of a barometer, show that under such conditions they had no means of sensing the approach of *sudden* storms."

The photographs of Foula opposite, in Plate IV, were taken on a meteorological reconnaissance flight on June 15, 1947, by Flt. Lt. F. R. Leatherdale, D.F.C., F.R.Met.S.

O.M.A

SCIENTIFIC INSTRUMENTS II *

Edited by H. J. Cooper, B.Sc., A.R.C.Sc.I., A.M.I.E.E.

293 pages; many illustrations. London: Hutchinson's Scientific and Technical Publications, June 1948. 30s.

This book is a sequel to *Scientific Instruments*, published in 1946. Its purpose was (to quote from the preface): " . . . that the worker in one field may get a useful idea of the instruments used in another. The book does not set out to tell the specialist about his own equipment but about the other man's." *Scientific Instruments II* is on similar lines (with the added advantage of an index), and will make the same appeal to all who are interested in the design and use of instruments.

Readers of *Weather* will probably turn first to the two chapters on meteorological instruments, one dealing with general and aircraft instruments, the other with electronic instruments, chiefly radiosondes. (Surprise at finding them in the section on " Astronomical and Navigational Instruments " is somewhat reduced on finding that the navigational chapters deal almost exclusively with aircraft.) The author is Mr. O. M. Ashford, head of one of the instrument-development branches of the Meteorological Office. As explained above, these chapters are intended for specialists in other fields rather than the professional meteorologist, but all will welcome this authoritative and up-to-date survey.

The first chapter deals with all the usual meteorological instruments for ground and aircraft use. Barometers are not described as they were dealt with in the previous volume; but it might have been mentioned that the Kew barometer there illustrated is not the type used by most meteorologists, and several other minor errors might have been put right. The various difficulties of measurements from aircraft are mentioned, but not the one perhaps most intractable, namely, the uncertainties (especially in temperature measurement) caused by the high air speed past the instruments.

The second chapter begins with a useful summary of the different types of radiosonde, giving the advantages and disadvantages of each. This is followed by a detailed description of British radiosonde practice, including the various methods of measuring upper winds. There is also a short account of the detection of thundery showers by radio and radar.

The other chapters cover a large variety of instruments, many of which have some bearing on meteorology. Of particular interest are a photographic pilot-balloon theodolite and a description of methods used for finding wind velocity from an aircraft. The chapter on " Strategical Computing Machines " (popularly known as " Electronic Brains ") reminds us that calculations which once took months can now be completed in as many minutes; the time may not be far distant when a rigorous solution of the equations of motion of the atmosphere becomes a possible basis of forecasting. J. R. B.

* Review

THE WEATHER OF FEBRUARY 1949

MILD, DRY AND SUNNY

February was in many ways remarkable. Pressure averaged more than 10 mb. above normal over much of the country ; in fact over the southern half of England and Wales it fell below 1,020 mb. on only six days. After a cold beginning to the month temperatures were mostly well above normal, while sunshine totals other than in parts of Ireland and Western Scotland were phenomenal, record figures being obtained in the Midlands, Southern and Eastern England. Rainfall was below average except in Western Scotland, much of England and Wales receiving only about half its normal quota ; this was the sixth successive month with a low rainfall in the South-East.

A large anticyclone over Scotland on 1st moved slowly south-eastward over the Continent and fair or fine weather with low screen minima (between 18° F. and 25° F. in many places and 11° F. at Rickmansworth, Herts), were fairly general inland and there was skating for a short time in East and SE. England. On 7th the anticyclone weakened and a westerly type of weather set in accompanied by milder conditions. On 9th a vigorous depression moved north-eastwards across South Wales and the Midlands ; gales associated with this depression were widespread to the southward of its path, Mildenhall recording a gust of 64 m.p.h

After a short spell of dull weather, a fine sunny period became established on 16th and continued for nearly a week. High maximum temperatures between 55° F. and 59° F. were common during this spell and for a few days afterwards when a very mild air mass with SW. to W. winds covered the British Isles. An unsettled, westerly type of weather persisted until 26th when pressure began to rise west of Ireland, the wind slowly veered and temperatures gradually fell.

While we in Britain were congratulating ourselves on our mild winter, we continued to hear of difficulties to be contended with in California where the winter seems to have been the coldest for 60 years and "Smog", a newly-coined word for smoke fog, is giving scientists much food for thought. Winter sports have, we understand, been spoilt by the mildness of the winter in the North-Eastern States while on 4th they were praying for rain in Vancouver. During the second week of February there was snow in Bagdad, and snowdrifts in Libya were proving a tough problem for British troops, while at about the same time Northern Queensland was experiencing a severe cyclone (tropical storm) that caused much damage to property at Cooktown.

	TEMPERATURE (°F.)				RAIN (mm.)*			SUNSHINE (hr.)		
	Long period Average		This month Extreme		Month	Diff. from Av.	Last 12 months	Month	Diff. from Av.	Last 12 months
	Max.	Min.	Max.	Min.						
Kew Obsy.	45·5	36·6	56	23	23	−16	473	106	+45	1585
Gorleston	44·2	36·2	57	27	27	−11	475	131	+56	1769
Birmingham	43·0	35·1	57	24	20	−23	753	109	+52	1417
Falmouth	47·8	39·5	†54	†38	38	−56	870	112	+32	1770
Valentia	48·5	41·1	55	34	93	−41	1344	61	−5	1276
Aldergrove	44·5	35·6	53	25	44	−20	827	74	+13	1315
Holyhead	45·6	39·9	51	26	28	−34	722	98	+23	1578
Tynemouth	44·1	36·8	55	27	12	−23	510			
Renfrew	44·1	34·6	54	25	117	+35	1290	57	+7	1233
Aberdeen	42·9	33·9	56	23	27	−27	784	111	+34	1502
Stornoway	44·7	37·1	53	29	141	+28	1283	63	+8	1214

* 25 mm. = 1 inch (approx.) † The Lizard C.R.B.

LETTERS TO THE EDITORS

The Aurora of January 24-25, 1949

This Aurora occurred about two days after a large sunspot group (covering 2,400 millionths of the sun's disc, at a latitude of 23°N) had crossed the central meridian of the sun.

It was first observed about 1900h. as a diffuse quiet arc, reddish in colour, low in the north. Occasionally diffuse rays appeared, running along the arc from E. to W. At no time was the luminosity or definition good enough in the early stages to provide measurable photographs. At 21h. 49m. 15s., the arc suddenly widened, while remaining diffuse, two rays shot up in the NE. and, all in the space of about five seconds, the arc and rays dissolved to leave only a residual weak red glow on the N. horizon.

The arc reappeared at about 2300 (4° above the horizon at Seaton, Cumberland) and at 2330 commenced to rise, passing directly overhead at Edinburgh about midnight. A rayed band then formed with two well-defined pillars of green light (tinged with red) at its east and west extremities. The arc was overhead at 0045 at Seaton, where simultaneously a corona appeared.

The most active phase of the display was from 0030-0330. At times, large areas were filled with closely packed patches of uniform luminosity, like bluish-white cirrostratus, each element being well defined and rapidly expanding and contracting, especially in the direction towards the magnetic zenith. The display was characterized not by the great brilliance of any particular auroral feature, but by the magnitude of the total light emission from the whole sky. With no moon, the landscape was so brilliantly illuminated that detail could be picked out on a hill three miles away. A colleague in Edinburgh claimed that the light awakened him. For a long period, activity was confined to the northwards of an E. to W. line of patches, most striking in its straightness, passing through the magnetic zenith. At another time, the sky up to 30° from the N. horizon was quite dark and devoid of any activity.

The white patches had ' body ' and were opaque like clouds ; the diffuse red surfaces which developed occasionally, appeared by contrast, diaphanous. The latter when present formed a continuous thin background to the brighter white patches and were undoubtedly at a greater height. When the patches alone were present, the rest of the sky appeared relatively dark. When at about 0300, the ' shreds and patches ' nature of the auroral elements changed to long diffuse draperies, there was not the marked contrast in intensity that had hitherto existed. The whole area surrounding the rays in the curtain emitted light, a remarkable difference from the main ' patch period ' when the background did not appear to emit at all.

On the next night (January 25-26) the sky was overcast but the intensity and colour of the transmitted light showed that there was very great auroral activity, with more colour than the previous night. Telephone operators at Perth reported even more interference from earth currents than on the previous night.

The University,
Edinburgh

JAMES PATON

I wonder if any of your readers were fortunate enough to observe the aurora during the night of January 24-25, 1949. Perhaps the most remarkable features of this display were its long duration and, secondly, the distance between stations where it was observed. I understand that it was seen in Southern England and, a night later, in the South of France.

At Prestwick, Scotland it was first seen shortly after 19.00 h. on the 24th and lasted until after 04.00h. the next morning. In its early stages, the aurora consisted of a single arc in the north-western half of the sky, and then pulsating bands of reddish-light became visible by 19.45h. The arc appeared to reach from 300° to 020° approximately. This primary display became less intense during the remainder of the evening. Towards midnight, however, the aurora had spread across half the sky, with bands of light displaying themselves from a crown in the zenith. Areas of a deep red-coloured hue intermingled with other pulsating bands, these being of a delicate shade of light "yellow-green." The aurora became faint towards 04.30h. when it was last observed.

An aurora of some intensity was presumably taking place again on the following evening and night, but owing to an 8/8 layer of thin alto-stratus, the display was hardly visible. The clouds were definitely illuminated and it was possible, on occasions, to distinguish bands of light moving across the sky.

It is interesting to recall the last intense aurora of January 25, 1938 which was visible

in this country and also in France. Interesting too, is the length of time that has elapsed since then, a period of eleven years, which is associated with the sun-spot cycle.

Prestwick Airport — IAN H. DOBINSON

EDITORS' NOTE. We have also received an interesting and detailed description of these aurorae from Mr. S. Szczyrbak who observed them from Coltishall, near Norwich.

Antarctic Weather Charts

During the recent war I was a lieutenant in the South African Meteorological Services, and for part of the time was a member of our Research Office in Pretoria. One of my duties there was the organization of our daily Southern Hemisphere Chart.

I would like to correct a statement in *Weather*, March 1948, page 92, and seven lines from the bottom, reading : " the resulting charts have an interest as constituting probably the first series to cover the greater part of the Southern Hemisphere for a period of several months." This is in reference to the 1946–47 Whaling Season. Actually the Southern Hemisphere Chart was drawn in our office as a matter of routine from June or July 1945, and further, blank charts were supplied by us for the 1945–46 Whaling Expedition. I do not know if these charts have been maintained by the civilian meteorological office or not, but were still being drawn in March 1946.

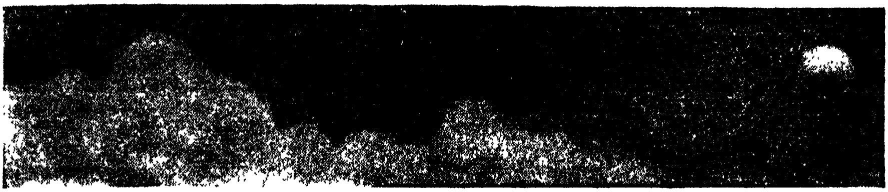
Queenstown, S. Africa — V. E. DIXIE

Referring to the letter from Mr. V. E. Dixie of Queenstown, S. Africa, the statement in question was contained in the account of my lecture to the Royal Meteorological Society, Scottish Centre, in Edinburgh, in February 1948.

I assume that Mr. Dixie is naturally anxious to put on record the work done under him in the South African Meteorological Service when he was a member of it. It seems unlikely, however, that his charts can have been completed in latitudes south of 50° S. Indeed, the title " Southern Hemisphere Chart " was somewhat misleading when applied to such charts as I was shown during my visits to Cape Town in 1946 and 1947 ; not only were there no observational data at all south of 50° S., except in the narrow quadrant 35–70° W., but the charts were confined entirely to longitudes between 70° W. and 90° E. (i.e. less than half the way round the hemisphere and zones north of 50° S. only). Mr. Dixie's charts at Pretoria may have been slightly more complete than that, but they can hardly have had any regular ships' data south of 50° S., as the whalers did not go south in 1944–45 and did not broadcast any reports in 1945–46. In the light of this the statement in *Weather* of March 1948 hardly seems extravagant.

However, it might be well to put on record that the South African Meteorological Service generously provided, free of charge, all the blank charts needed for the whaling expedition in 1946–7, which I accompanied (and for that in 1945–46, when, however, the charts were not used), and that that service in its research division in Pretoria had been itself experimenting with the possibility of drawing daily charts of weather over the Southern Hemisphere from 1945. Lack of ships' reports in the Southern Ocean must have restricted the range of the charts at first, but the opening of new synoptic stations on Prince Edward Island, Heard Island and Macquarrie Island in 1948 must now have opened new possibilities.

Dunstable, Beds. — H. H. LAMB



APRIL 1949

WEATHER

Vol. IV No. 4

CONTENTS

EDITORIAL

Of the many "interests" which make use of the government meteorological services, which group should be considered first ? It was the seamen who first persuaded Treasury to spend money on meteorology, but airmen now have the biggest say in determining the policy of the Meteorological Office, which since 1920 has been a department of the Air Ministry.

The requirements of agriculture were discussed last month at meetings of the Royal Meteorological Society in Edinburgh and London (see page 125). The claim was made that farmers have more to gain than anyone else from a suitable meteorological service, and that the growing of food is more important than sending an aircraft from A to B. Considering that agriculture is our greatest industry—producing more worth of goods than the coal mines and the iron and steel industry together, and 1½ times as much as the navy and air force spend between them—this claim deserves to be taken seriously. With shortages of labour and the increasing size of his operations, the farmer is having to plan his work more carefully and further ahead than ever before. The repercussions of an unlucky decision or a missed opportunity persist throughout the whole season.

If it is really true that weather forecasting and research have important parts to play in increasing our crops and reducing their cost of production, then perhaps it would be wise to consider once again the setting up of a state meteorological organization, independent of the armed services and of all sectional interests. It would be tragic if what began as a protection for mariners against the dangers of foul weather should come to be regarded largely as a weapon of war.

"MET.'S MY HOBBY"

"What on earth do you get out of it?" I am faced with this question so frequently when my hobby comes under discussion, and it is so difficult to answer in a few words, that it may be worth while attempting to do so at some greater length here. The obvious answer is that I find meteorology much more interesting than horses, dogs, or football pools, and a great deal less costly than any of these can become; and here I come to another remark that I hear so often.

"It must be costing you a fortune!" Of course it isn't. One of its chief charms is that you can make it as inexpensive or as costly as your means and inclinations dictate. The amateur who amuses himself in a leisurely way by sketching clouds spends very little on his hobby, and if he makes a few notes on the back of each sketch descriptive of present and subsequent weather, he is taking a very intelligent interest, which is not unlikely to produce some useful results. If he can run to some £3 a year for the *Daily Weather Report*, and one or two elementary books, he can find further interest in linking his notes and sketches with world conditions. Such suitable reading of a non-technical nature can be found, for instance, in *Weather Study*, by D. Brunt, published in Nelson's "Aeroscience Manuals"; in *Cloud Forms* (His Majesty's Stationery Office); *Weather*, by R. Abercrombie, revised by A. H. R. Goldie; and *Clouds and Weather Phenomena*, by C. J. P. Cave (Cambridge University Press).

At the other end of the scale is the more fortunate amateur with a quarter of an acre of land and a few hundred pounds which he is able and willing to devote to his study, and who can equip a comprehensive observatory and enter into very active co-operation with the Meteorological Office by reporting his observations regularly.

In between is a wide range of activity, governed by the keenness of the amateur and his means of equipping himself, and guided by the branch of this very extensive subject which commands his interest. For the mathematical student, for example, the statistical treatment of the immense mass of data published in the *Monthly Weather Report* can prove an inexpensive and absorbing pastime, with the possibility of some useful original work and without the expense and tie of taking his own observations.

Into whatever field his interest may take him, he will always find that those who really know something of the subject are interested in him and what he is doing. This was one of the most unexpected discoveries I have made, and in this connexion I cannot too strongly recommend the keen amateur to become a Member of the Royal Meteorological Society. The facilities provided, not to mention the opportunities for personal contact with world-famous meteorologists, make membership very valuable to the really keen amateur. It is the only means of filling the gap left in his activities by his inability to participate in laboratory research, the cost of which is prohibitive to all except the most opulent, as the professional research personnel are most surprisingly willing, and even anxious, to remove the obstacles from the path of the meagrely informed dabbler. The conservative and absent-minded professor familiar to the reader of popular fiction is an extinct species, if he ever existed. The meetings are conducted with a minimum of formality, and the papers presented are usually toned down for the comprehension of the non-professional Fellows, who now form the majority of the membership.

Private observers are also invited to co-operate with other organizations engaged in atmospheric research, such as the Gliding Association and the British Thunderstorm Survey, and much useful as well as interesting work is done through this co-operation.

One thing the amateur will do well to resist is the temptation to dabble in forecasting. Besides being a very highly skilled job, this necessitates the possession of a vast amount of data many hours before it is available to him. Though he may amuse himself by trying to deduce the general appearance of today's weather-chart from a study of those of the past two or three days, the changes in the shapes of isobars are likely to be so frequent that any resemblance between today's and yesterday's configurations may be completely unreal and lead to altogether erroneous assumptions. If, however, he is of that mental make-up which likes to assume an appearance of weather wisdom for the benefit of his neighbours, he can indulge in a little harmless cheating by tuning in to " Airmet " and secure a very reliable " prompt " for his forecasts for some five or six hours ahead.

My own interest runs mainly to the comparison of the weather of one year with that of another. For this purpose I have selected three representative elements which collectively cover the greater part of weather phenomena, namely temperature, sunshine and rainfall. For purposes of comparison I divide each year into 73 short periods of five days and five " seasons " of 73 days. Of course, periods of any length may be employed, but these numbers are useful as being the only integral factors of 365, so that there is only one interruption every four years to the regular sequence of comparable periods of equal length. At the end of each period I plot maximum and minimum temperatures, sunshine total in hours and tenths, and rainfall in inches and hundredths. I find the histogram more eloquent than the curve, so fill in my temperature range from maximum to minimum and sunshine and rainfall from total to zero on squared paper. To increase the eloquence of the picture I add a " tail " in red ink under the minimum temperature, to represent grass minimum. If these three graphs are plotted, one below the other, on the same sheet, and if suitably related scales are employed, a very clear picture of the general weather conditions of the site for the year can be obtained, and by plotting subsequent years in spaces adjoining the same periods of the first year recorded an eloquent comparison is shown at a glance. A similar graph of the selected elements is also interesting if successive periods are included in sequence, to show the progress of weather throughout the year under review. This, of course, is only one way of arranging the data. Each dabbler will, no doubt, devise his own methods, this being one of the most interesting aspects of the hobby.

A. J. WHITEN

ANTARCTIC EXPEDITION, 1949-52

In November 1949, 14 men, including two scientists each from Norway, Sweden and Britain, will arrive at Queen Maud Land, latitude 70° S. The first number of *Tellus*, the Swedish Geophysical Society's new quarterly journal, gives details of the arrangements. The Norwegian, Professor H. U. Sverdup, will lead the expedition, whose objects are exclusively scientific and will be divided into three main parts. Sweden will be responsible for glaciology, Norway for meteorology, and Britain for geology.

The meteorological programme includes a study of wind structure and the determination of incoming and outgoing radiation. Radio-sondes and radar wind measurements will be made daily in co-operation with other stations in the Antarctic.

ATMOSPHERIC ELECTRICITY DURING THE LAST 50 YEARS

By Sir George C. Simpson, F.R.S.

From a popular lecture to the Royal Meteorological Society on January 12, 1949, summarized by A. R. Meetham, D.Sc.

Part I. The Normal Electrical Field in the Atmosphere*

"In October 1905 I read my first paper before the Royal Meteorological Society. It was entitled 'Normal Electrical Phenomena of the Atmosphere', and I reviewed what was then known of the subject. Since then I have devoted the larger part of my scientific work to the problem of atmospheric electricity, and I shall now review the progress which has been made in this period of nearly fifty years. This will involve my describing work in which I have personally taken part ; but I trust you will not think that I do this with any object of self praise : I can assure you that the number of theories which I have put forward only to abandon or modify them tends to humility and not to pride."—*From opening remarks of lecture.*

Atmospheric electricity has many aspects : the electricity of normal fine weather, the electricity of disturbed weather,† and the electricity of thunderstorms.† The problem of the origin of the normal electrical field, which will be considered here, is interesting because of the unexpected conclusions reached and the developments to which it has contributed in other branches of geophysics.

First it is necessary to quote some definitions from the school textbooks. In the space between two electrically charged bodies there is an electrical stress causing them to be mutually attracted or repelled. We call this stress the field strength or more generally *the field.* It has long been known that there is an electrical field in the lower atmosphere, and it has been measured in all parts of the world. We do not measure the strength of this field directly, but we measure what is called the *potential gradient*—that is the energy required to move a charged body in a vertical direction—and from these measurements we can calculate the strength of the field and the charge on the ground necessary to produce that field. When I mention the electric field or the potential gradient I am simply referring to the strength of the electrical force, and indirectly to the charge necessary to produce that electrical force.

My last point is that the charge on the two bodies cannot leave those bodies in air, because the air is a non-conductor of electricity. This is because ordinary air is composed of neutral molecules ; but by a process called *ionization* some of the molecules lose negative electrons, leaving them positively charged, while the freed electrons are absorbed by other neutral molecules. As a result some molecules have a positive charge and some a negative charge. These charged molecules are called *ions*, hence the expression ionization for the process by which they are formed. " Ion " is the Greek word for " wanderer " and was given to them because, when placed in an electric field, the

* Parts II and III will appear in "*Weather*" for May and June, 1949.

† See *Quart. J. R. Met. Soc., Vol.* 68, *pp.* 1-34 (*Presidential Address,* 1942.)

ions wander along the lines of force, the positive in one direction towards the negatively charged body and the negative in the opposite direction towards the positively charged body. The movement of the ions is equivalent to an electrical current and that is why we say that ionized air is a conductor of electricity.

EARLY IDEAS

The presence of electrical forces in the atmosphere was first suggested in connexion with thunderstorms and nearly 200 years ago Dalibard in France and Franklin in America confirmed this suggestion. It was soon found however that an electrical field could also be detected in the atmosphere in fine weather, and without even the presence of clouds. This field was studied and it was found that in fine weather the field could be detected everywhere : on land and on sea, on plains and in the mountains, in the northern hemisphere and in the southern hemisphere ; it was always directed in the same way as though there was a charge of negative electricity distributed over the whole surface of the earth. It was also found that the field strength had a regular annual and daily variation ; it was greater in the winter than in the summer and at certain hours of the day that at other hours. This was practically all that was known in the year 1898.

There were of course a lot of theories, hypotheses, and suggestions as to the origin of this electrical field and the cause of its daily and annual variation. The theory then most generally accepted had been set out by Professor Exner of Vienna in 1890. According to this theory, when the earth was formed it was not electrically neutral but had a residual charge of negative electricity, the charge being all collected on the surface according to the ordinary laws of electrostatics. It was believed that the atmosphere was a non-conductor of electricity, so this charge could undergo no loss and must remain the same in total amount for ever : on the other hand when water evaporated from the surface some of the electrical charge was carried with it, so that the total charge was shared between the surface and the lower atmosphere. As the water in the atmosphere has an annual and a daily variation, there would be a similar variation in the electrical field, and when he wrote his paper Exner was attempting to prove this relationship.

A GREAT DISCOVERY

All these speculations were however cut short by an epoch-making discovery made in 1899 by C. T. R Wilson in England and by Elster and Geitel in Germany. They found that the atmosphere in its natural state is ionized ! The degree of ionization was not great, but it was sufficient for an insulated charged body to lose five per cent of its charge each minute.

This altered the whole problem of atmospheric electricity, for if the atmosphere is ionized any residual charge left on the earth at its formation could not be retained on the surface. It would be driven to the uppermost conducting layer of the atmosphere. By another of the laws of electrostatics

there can be no electrical field within a conducting body, so the field which is observed in the atmosphere near the ground cannot be due to a residual charge such as was suggested by Exner. We have therefore to seek for another cause of the charge on the ground other than a residual charge.

Elster and Geitel, having been responsible for this new problem by discovering the ions in the atmosphere, naturally made an attempt to find a solution, and in 1901 they put forward the following ingenious theory. Zeleny had made certain experiments which he interpreted to mean that when positive and negative ions are in an electrical field the negative ions move through the neutral molecules of air quicker that the positive ones, or as we should say now negative ions have a greater mobility than positive ions. Now let us consider an insulated conducting sphere surrounded by ionized air. Each ion near the surface will induce an opposite charge on the sphere and will be attracted. The attracting force will be the same for positive and negative ions but the latter, having the greater mobility, will reach the surface first. Thus the sphere at first receives more negative than positive ions and so becomes negatively charged. This charge goes on increasing until the field set up by it increases the movement of the positive ions, and decreases the movement of the negative ions, until the rate at which positive and negative ions reach the body is equal, when the charging ceases. Elster and Geitel applied this reasoning to the earth's surface, and considered that the negative charge which is always found on the surface in fine weather is the charge necessary to counteract the greater mobility of the negative ions.

With the remark that a wind would be necessary to remove the positive ions from the neighbourhood of the surface, C. T. R. Wilson accepted Elster and Geitel's theory. But there were still difficulties for when Villari repeated Zeleny's experiments he found that bodies exposed to ionized air became positively charged which is just the opposite to Zeleny's result, on which Elster and Geitel's theory was based.

MY EXPERIMENTS IN GÖTTINGEN

This was the position when in 1902 I was awarded an 1851 Exhibition Scholarship and decided to go to Göttingen to study atmospheric electricity under Professor Wiechart. I was naturally interested in the problem of the origin of the earth's negative field and undertook a research to test Elster and Geitel's theory, and if possible to repeat Zeleny's and Villari's experiments to see if they could be reconciled. I was able to show that there was no contradiction between Zeleny's and Villari's results; the apparent difference was simply a matter of the experimental arrangement. It was clear that Zeleny's experiment could not be directly applied to the problem of atmospheric electricity for the conditions in the experiments have no parallel in the atmosphere. To clinch the matter I suspended an insulated metal within a large wire cage and measured its potential, but it was only a small one and different metals reached different potentials and then remained constant. The cage I used was of zinc-coated iron wire, and when I examined the end potentials of

the different metals I found that in each case it was exactly the voltaic difference of potential between the zinc and the metal being tested. Copper and iron are positive to zinc and these metals charged up positively, while magnesium and sodium which are negative to zinc acquired a negative charge. Thus it was quite clear that insulated conductors, when placed in ionized air, do not obtain a negative charge on account of the difference in mobility of positive and negative ions. A description of this work was the first paper I published on atmospheric electricity, and the result was at once accepted and Elster and Geitel dropped their theory.

THE CHARGING MECHANISM

Elster and Geitel's theory of charging by ion absorption having been disposed of, there was a spate of new theories but none of them carried conviction. A brief restatement of the problem will bring out the difficulties with which we were faced.

We know from the observations that there is a negative charge over the whole surface of the globe, except in areas of disturbed weather where there is generally some rain or snow. Neglecting for the moment the latter and fixing our attention on the fine weather areas which comprise the greater part of the whole surface, we have to picture an electrical field associated with the negative charge which extended as high as observations had then been made. Owing to this field negative ions are moving upwards and positive ions downwards at such a rate that the whole charge on the surface would need replacement in 20 minutes if it is to remain constant. At the same time the source of the positive ions moving downwards would also require replenishment. Therefore it is clear that there must be some process acting in the atmosphere which replenished the negative charge on the ground and the positive charge in the upper atmosphere. The problem was to find this process.

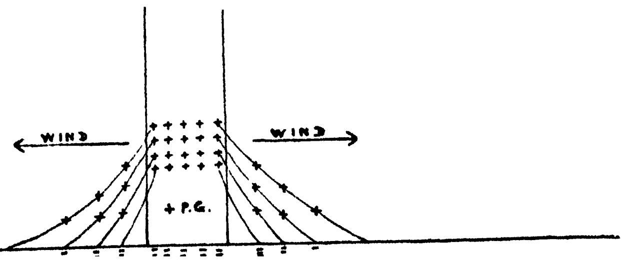


Fig. 1. Attempt to explain the charging process.

As the loss is taking place in all fine weather areas it is natural to look for the mechanism of replenishment in the areas of precipitation. At that time it was thought that rain carries to the ground negative electricity ; if so, the corresponding amount of positive electricity must be left behind in the clouds. This seemed a simple and satisfactory solution, for the rain provided the negative charge to the ground and at the same time provided an equal quantity of positive electricity to the upper atmosphere. These two charges came together

again in the areas of fine weather. The problem is however not so simple as all that, as we shall see if we look more closely into the proposed mechanism.

Figure 1 shows an area of precipation surrounded by fine weather. The precipitation is supposed to bring down negative electricity, leaving positive electricity in the clouds. The negative electricity in the ground is " bound " by the positive electricity in the clouds and therefore, in the absence of wind, cannot flow into the fine weather area. But let us suppose that the wind carries the air from the disturbed region into the fine weather area. The clouds disappear and the positive charge goes into the air as free ions and moves downwards in the electric field. Thus the positive charge which was in the air moves towards the ground ; calculations show that within an hour of the positive charge entering the fine weather area it has all reached the ground and no supply of electricity can be carried further by the wind. Now there are many desert regions, extending over hundreds of square miles, which cannot be reached in several hours by the existing winds coming from regions of precipitation, yet the potential gradient in these areas is positive and of normal strength everywhere. Thus we see that fine weather areas cannot in this way draw their supply of negative electricity from regions of rainfall. There is a further difficulty : in the precipitation area the potential gradient is required to be positive while we know from observation it is negative. This reasoning does not apply only to replenishment by precipitation, but to all forms of separation which take place outside the fine weather areas.

This article will be continued next month with an account of C. T. R. Wilson's theory of the charging mechanism, now generally accepted.

NEW FELLOWS OF THE ROYAL SOCIETY

Among the 25 fellows recently elected by the Royal Society, the following have close connections with meteorology and allied sciences :

BAWDEN, Frederick Charles. Head of the Plant Pathology Department at Rothamsted Experimental Station, Harpenden. Distinguished for his work on plant viruses and virus diseases.

BULLEN, Keith Edward. Professor of Applied Mathematics in the University of Sydney. Distinguished for work in geophysics, particularly in relation to earthquakes and the distribution of density within the earth.

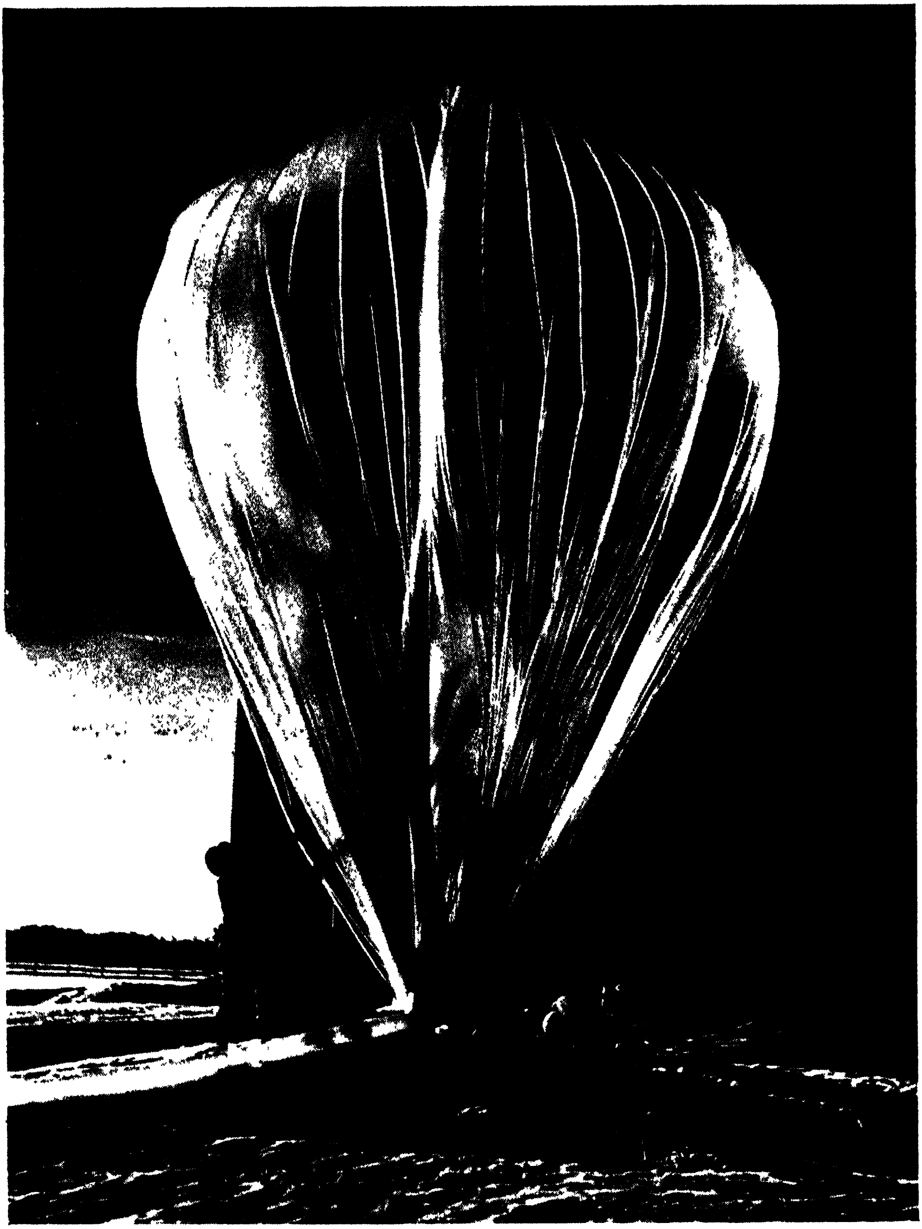
SUTHERLAND, Gordon Brinis Black McIvor. Reader in Spectroscopy, Department of Colloid Science, University of Cambridge. Distinguished for his experimental researches on infra-red and Raman spectroscopy.

SUTTON, Oliver Graham. Professor of Mathematics and Physics, Military College of Science, Shrivenham. Distinguished for his researches in atmospheric turbulence and evaporation.

Readers of *Weather* will be particularly pleased to see the name of Professor Sutton, who has contributed articles on " Smoke from Factory Chimneys " (August 1947) and "The Atomic-bomb Trial as an experiment in convection" (April 1947). Professor Sutton recently gave a most interesting account to Meteorological Office staff, at the invitation of Sir Nelson Johnson, of research work on micrometeorology in N. America. A report of this meeting will appear shortly in *Weather*.

George C. Simpson in Lapland, 1903, to measure the potential gradient in high latitudes.

PLATE I



Inflating the *Skyhook* balloon. When fully expanded at a height of 100,000 ft., the balloon has a diameter of 70 ft.

By courtesy of] *U.S. Office of Naval Research*

PLATE II

WEATHER OVERSEAS

STRATOSPHERE—BALLOON FLIGHTS

Extracts from an article, by Lt. Comdr. B. H. Hickman, USN, which first appeared in an official report; published by kind permission of the Office of Naval Research, Navy Department, Washington, D.C.

Unmanned stratosphere balloon flights are being made at a level higher than that probed by aircraft and below the level of space probed by rockets, i.e. 50,000 to 100,000 ft., to learn more about cosmic rays and nuclear physics, biological phenomena, accuracy of meteorological instruments, temperature and humidity, and the force and direction of winds aloft. The special non-extensible balloons, manufactured out of polyethylene in 0.001 gauge material, are pear shaped in design and require extreme care and precision in handling because of their fragile construction. When fully expanded at an altitude of 100,000 ft., the balloons are 70 ft. in diameter and 100 ft. in length; the unloaded weight is 100 lb. Plate II shows one of the balloons being inflated. To aid in the recovery of the instruments carried by the balloons, they are tracked by radar from four different points. Unlike rubber balloons they can remain at high altitudes for a long time.

One of the most interesting possibilities for research using these balloons is in the field of meteorology. No vehicle has previously been developed which is capable of carrying instruments so high and remaining at a constant pressure level for long periods of time As a consequence, all texts written on airflow and temperature at 100,000 ft. have been only theory. Recent stratosphere flights under this project—known as project *Skyhook*—have indicated that there is a strong possibility of these theories being entirely wrong. It was thought that airflow at this level was from west to east at a constant high velocity. In tracking the balloons visually, with radar and theodolites, it appears that above Minnesota the winds are very unpredictable, varying from 0 to 120 knots in speed and from east to southwest in direction; not only does the airflow vary from day to day, but virtually from minute to minute. These data should be of immense value to the designers and operators of high altitude aircraft.

Because of the unprecedented nature of these flights, special safety precautions have been adopted. For instance, balloons must only be launched in clear weather and a means has been devised of ripping the balloon and thereby terminating the flight after four hours. In future the balloons will be tracked by an aircraft, equipped with an inverted search-type radar; when this is in operation, it is hoped that the recovery rate will be close to 100% and that some of the restrictions on weather conditions will be lifted.

Since this article was originally prepared, a more detailed paper describing work carried out with these new balloons has been written by A. F. Spilhaus, C. S. Schneider and C. B. Moore (see *Journal of Meteorology*, August 1948). The authors suggest that one function of the balloons to the meteorologist is the same as that of the drift bottle to the oceanographer.

SHELTER AND EXPOSURE IN WEST ANGLESEY

THE CLIMATOLOGICAL FREQUENCY DISTRIBUTION DIAGRAM AS AN AID TO LOCAL FORECASTING. PART I.

By FRANK A. BARNES, B.Sc.

The competent local forecaster must be something of a climatologist. His operations go beyond those required in constructing the general area forecast. This latter is largely based on analysis of the synoptic situation, its forecast development, and a general study of the air masses involved. The local forecaster must take into account also the detailed peculiarities of his locality. This implies especially a knowledge of shelter and exposure effects with air-streams moving from all directions. The environmental controls may frequently be significant enough to cause local temporary systems of wind and weather to develop, which may make the locality distinctive in climate. Sea breezes and valley winds and their meteorological consequences are examples of such systems. Such local effects must be investigated and understood before it is possible to produce a reliable local forecast. A method of conducting such investigation is described below.

For use in day to day forecasting, evaluations of single meteorological elements are of little value. For practical use, climatological studies must be concerned with causal relationships, and may justifiably show a comparative rather than a quantitative relation. The latter, if carried too far, would not only be infinitely laborious, but would lead to a detail too close to be of practical value. The following diagrams were constructed for use at Valley, in W. Anglesey, a few miles from Holyhead, and about one mile from the sea at the most westerly point of the Anglesey mainland. Their practical value rests in their correlative nature, while the frequency-isopleth method used makes visual interpretation easy, and allows three variables to be represented in one diagram, which becomes, as it were, a graph in three dimensions.

The notes on the " Weather of October 1946 " (*Weather*, November 1946) emphasized the abnormally high sunshine figures and the low rainfall at Holyhead in consequence of the persistent E. to SE. type of weather which characterized the month. " The immediate benefit (to Holyhead) of the shelter of the Welsh mountains with SE. winds " was pointed out. The weather and climate of any place on land are determined, in some degree, by the effects termed " shelter ", and its converse, non-shelter, called " exposure ". These terms are comparative, and may equally well emphasize the contrast between weather approaching over mountain and plain or over land and sea. In Anglesey they are of great significance, because of the nearness of the sea on the one hand and the mountain masses of Wales on the other. The effects are not always easy to evaluate, or even to discern in summaries of single meteorological elements. They may be qualitatively evaluated by studies correlating the previous track of the air-stream, in terms of orography, with particular weather elements. Wind speed, as well as direction, is obviously important.

The diagrams for W. Anglesey show the contrasting effects of shelter and exposure very clearly, because there is a rapid change, on moving round the compass from SSE. to SSW., from very effective shelter by the Welsh Mountains, to practically full exposure. Ireland and Scotland are also recognizable as sheltering agencies, though their effectiveness is more dependent on the type of air mass, time of day, and subsequent track. Ireland is particularly significant because the prevailing winds so frequently cross it. By contrast, winds reach Anglesey across the Welsh Mountains less frequently.

It must be recognized that the following studies are only aids to forecasting, and must be used in conjunction with all the other information (including air-mass characteristics, stratification, and sea temperatures) which may be at the disposal of the forecaster. The sparser this other information the more valuable, proportionately, does the climatological diagram become. In either case some knowledge of the physics of the atmosphere is necessary.

It is not proposed to examine in great detail the conclusions which may be drawn from the diagrams, but only to note certain outstanding points.

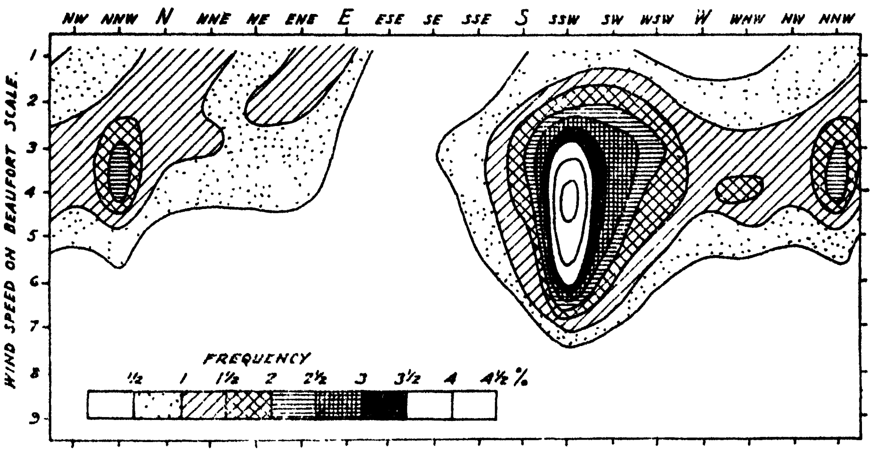


Fig. 1. Distribution of frequencies of winds according to speed and direction at Holyhead (Valley); from hourly observations, June, July and August 1942–1945.

WIND

Fundamentally, weather changes at a place are expressive of the movement of air masses and the changes they are undergoing by interaction with other air masses, with the surface over which they move, and within themselves. Investigation of wind distribution must, therefore, precede any correlative study relating wind with other variable elements.

Figure 1 shows the pattern of summer wind distribution at Valley for the period 1942–1945 inclusive. It is constructed from hourly observations over the months of June, July and August. Frequencies of occasions of each wind direction and strength on the Beaufort scale were entered in the diagram at the mid-points of the appropriate divisions (16-point direction scale) and iso-

pleths drawn on this basis. As in all such diagrams (including isobaric charts), quantitative accuracy at random points is sacrificed in favour of the clarity of impression which is necessary for easy analysis and comparison.

Figure 1 includes all winds over the period. Local winds, such as sea breezes and land breezes, are included with winds of more distant and general origin. Examination of winds at Valley on days of light winds and thin or broken cloud (by the frequency-isopleth method shown in Figure 2 for occasions in August) for periods of varying length and season has helped in isolating such local phenomena. Because the days used were often not consecutive, and because the day is a somewhat arbitrary period of time, meteorologically,

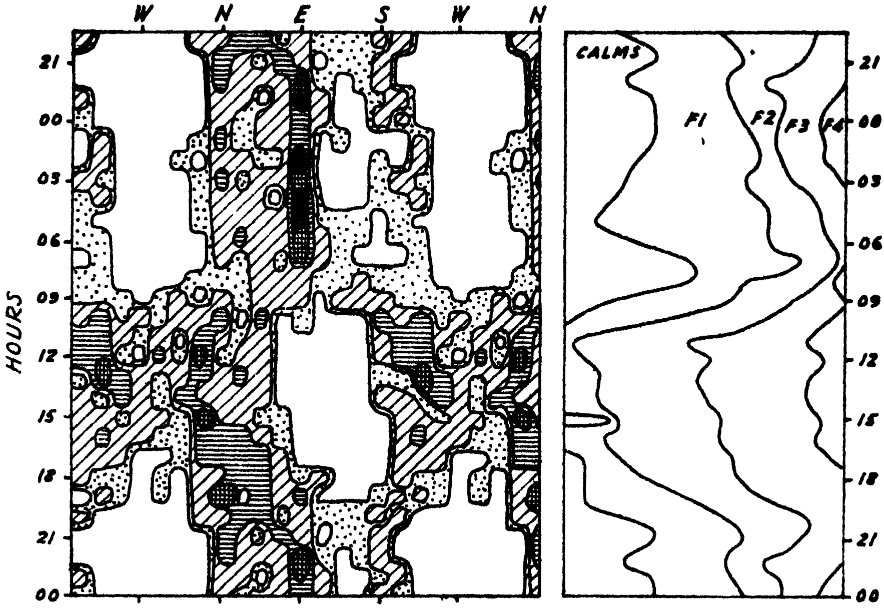


Fig. 2.

Frequency distribution isopleths of wind direction at Valley on " sea-breeze days " in August (from hourly observations for 28 days in August 1942–1945 inclusive).

Diurnal distribution of wind speeds on the same days

the late night or early morning winds may not satisfy the " sea-breeze day " criterion, and must be treated with caution. Then interpretation reveals :

(*a*) A sea breeze, varying between N. and NW., and of strength Beaufort force 2 to 4—the " turnover " sea breeze.

(*b*) A sea breeze from between S. and W.—the " diversionary " sea breeze.

(*c*) A night breeze (land breeze) of force 1 to 2, associated with many calms, blowing from E. to ENE.

(*d*) A night breeze, also very light, from about N. to NNE., not well developed in the August diagram, but very prominent in those for the earlier summer months when the sea is colder.

The diurnal variation curves for temperature and humidity on the same days show comparatively sudden flattening at the times of onset of these breezes. This helps to confirm the conclusions regarding their nature.

When the corresponding minor maxima in Figure 1 are reduced, a comparatively simple and striking picture remains. There is a huge maximum of winds from about SSW., especially dominant for stronger winds, and a remarkable paucity and lightness of winds from between SSE. and E. The normal distribution of winds over Anglesey, based solely on the general pressure distribution, certainly involves a maximum of winds from between S. and W., though nearer SW. than SSW., and not so a greatly marked. There is also smaller frequency from between S. and E. The contrast between the two directions is, however, less exaggerated and less sudden than that shown by Figure 1. Even though the period used is short, two inferences may be drawn :

(*a*) Many winds from SSE. to E. are " damped out " by the Welsh Mountains, and are represented in the frequency diagrams as occasions of sea-breeze or land-breeze directions, or become calms. The shelter effect is clearly demonstrated.

(*b*) Some winds, particularly strong winds, from SSW. to SW. directions, are " canalized " into a SSW. to S. direction. More detailed analysis, using a 32-point direction scale, shows S by W. to be a very frequent direction with stronger winds. This canalization is apparently due to the interference of the mountain mass with free air movement, perhaps reinforced by the influence of Ireland and its eastern hill masses. It may be more satisfactorily thought of as being due to the formation of a slight ridge by the " piling-up " effect of the air-stream against the mountain barrier. Such a configuration may often be seen on the synoptic chart on the windward side of mountains when strong winds are blowing. It is often strongly enough marked at Valley to give a surface wind greater than the speed of the air-stream at a level free from the effects of surface friction.

By examining Figure 1 it has been possible to recognize only the sheltering effect of the Welsh Mountains. When an air-stream crosses a range of hills it maintains its momentum at levels well above the mountains. The mixing and friction of successive layers of air causes this momentum to be gradually transferred down to the lower layers again. On the lee side of the mountains the surface wind speed and direction, normally proportional to the air-flow at a level above the influence of surface friction, is therefore restored at some distance beyond the range. Valley is near enough to the Welsh Mountains for their influence of shelter to be still strongly felt at the surface. Winds from the north and west, by contrast, approach Anglesey across at least 50 miles of sea, and the sheltering effects of Ireland and Scotland are nullified. The influence of air-flow across Ireland and Scotland as it affects cloud conditions, humidity and precipitation, however, may often be discerned when the air reaches Anglesey.

The concluding part of this article dealing with rain, humidity and cloud, will be published in the near future.

ICE IN THE ATMOSPHERE

By G. M. B. Dobson, D.Sc., F.Inst.P., F.R.S.

After the Annual General Meeting of the Royal Meteorological Society on January 26, 1949, the retiring president, Professor G. M. B. Dobson, F.R.S., gave an address on " Ice in the Atmosphere ". This subject had been discussed by the Society as recently as last November, he said, and he might be thought to be flogging a dead horse. But the horse was not at all dead ; its hinder part was so young that it had not even been broken in.

He first reminded his audience that at any temperature below freezing point the vapour pressure is greater over water than over ice ; hence when water droplets and ice particles are both present there must be a steady transfer from water to ice. The rate of transfer is greatest at temperatures of about 260°A. (where 273°A. is the freezing point), but even then the process need not be particularly rapid, because if ice is only 1° warmer than water, the vapour pressures are equal.

The vapour pressure over water is further modified if the water exists as a very small drop, in which case the saturation vapour pressure is increased. The same increase of vapour pressure was sometimes assumed to be true for very small ice crystals but Sir George Thompson in the Guthrie Lecture of the Physical Society recently showed that the growth of a crystal was so complex that the thermodynamic arguments applied to drops were unlikely to be true for crystals.

SUBLIMATION NUCLEI

Professor Dobson showed that sublimation nuclei on which ice particles can form are much rarer than condensation nuclei round which water condenses. He discussed some of the work of Aitken, and C. T. R. Wilson, the work done at the Clarendon Laboratory, Oxford, by Cwilong, Fournier d'Albe, Brewer, and Palmer, and that of Findeisen, Schultz, and Weickmann. In the laboratory one substance, cadmium iodide, had so far been found on particles of which ice would accumulate from air which was supersaturated with respect only to ice and not to water. Even cadmium iodide particles had first to be cooled to 232°A. in air supersaturated with respect to water before they acquired this property, and afterwards they had to be kept cooler than 263°A.

In the open air Findeisen and Schultz, and afterwards Palmer, had found about one nucleus, per litre, which would initiate the formation of ice if the air were supersaturated with respect to water. This was probably just enough to account for the number of ice particles observed in clouds and to be consistent with Bergeron's theory. Most laboratory experiments had to use too small volumes of air for these " Findeisen " nuclei to be encountered ; whereas observations in clouds, while enabling the nuclei to be counted, were subject to the disadvantage that temperatures could not be accurately measured. It was necessary to piece together all the information available from the laboratory

and the open air, and Professor Dobson summarized this as follows :

Above 273°A. (0°C.) the properties of condensation nuclei are well known.

273-263°A. the only known nuclei form water drops ; it is not yet certain if there are a very few Findeisen nuclei.

263-241°A. a few Findeisen nuclei are present.

241-232°A. ordinary outdoor air has nuclei which form ice as soon as supersaturation over *water* is reached, but a much larger number of condensation nuclei are present, and clouds always contain many more water drops than ice particles.

232-210°A. all nuclei form ice as soon as supersaturation over *water* is reached, and most clouds seem to be largely or wholly ice.

Below 210°A. (approx.) according to Cwilong the nuclei become less active, and fewer ice particles are found.

At 180°A. (approx.) a very few, large, ice particles are formed.

The temperatures are known quite accurately except at the lower end of the scale. The value 232°A. is a very definite temperature : all kinds of artificial nuclei, including those produced from evaporation of salt sprays and those emitted from red-hot platinum, formed ice as soon as they were cooled to 232°A. in supersaturated air. It must be concluded that some fundamental property of water changes at 232°A.

Applying this knowledge to actual clouds, great difficulties due to our lack of knowledge about the atmosphere are encountered, but it seems certain that ice occurs at much higher temperatures than might be expected from the laboratory work : 259°A. in cumulus, and 267°A. in stratus ; Frith had found pure ice clouds at 253°A. Evidence was still uncertain whether or not the freezing of water drops is an important process in the atmosphere.

WINTER SUNSHINE FOR BRITAIN

Referring to Langmuir's work on the artificial nucleation of clouds, Professor Dobson mentioned that in the laboratory the addition of a suitable number of particles of solid carbon dioxide (temperature 194°A.) to an artificial water cloud at temperatures below freezing would clear it away in almost a magical manner. It was too early to say whether the seeding of clouds with dry ice will be an important method of producing rain ; successes seemed to require a rare combination of circumstances. There was another possible application which might appeal especially to townsmen in Britain. Winter anticyclones were frequently accompanied by large uniform stratus cloud, producing dull, depressing weather and causing the use of much gas and electricity for lighting. If the cloud is below freezing point, seeding with dry ice from aircraft should clear it away at a quite small expense, with results that would be an advantage both economically and psychologically.

Mr. E. Gold proposed the formal vote of thanks to the President for his Address and for his services to the Society in the past year. He now knew that Hamlet was thinking of meteorological matters when he said "There are more things in heaven and earth, Horatio, than are dreamt of in our philosophy", and by heaven Hamlet obviously meant the air above the freezing level.

A.R.M.

THE "SIR NAPIER SHAW" COMPETITION

To commemorate the work of Sir Napier Shaw the following prizes are being offered for the year 1949 :

JUNIOR SECTION Age 15 to 21 1st Prize value £5
2nd Prize value £3
3rd Prize value £2

Subject The best description of any weather phenomena actually witnessed at any time by the entrant. The description should be as short as possible and in any case less than 1,000 words in length, and if possible should be illustrated by a sketch or photograph.

SENIOR SECTION Open to any entrant not a professional meteorologist.
1st Prize value £10 2nd Prize value £5

Subject The best description, photograph, film or drawing (or combination thereof) of any of the following actually witnessed by the entrant :

Any meteorological phenomena associated with earthquakes or volcanoes.

Any lightning storm or series of lightning storms.

Any cloud phenomena of the rarer sort such as a " Sydney Buster ", a " Pampero " or a " Haboob ", or sand devils in a desert.

The clouds associated with any tornado or waterspout.

An example of " St. Elmo's Fire ".

The effect of any meteorological factor(s) on agriculture, industry or any industrial process, or on any public utility.

The effect of any meteorological factor(s) on plant, insect, or bird life.

Any optical meteorological phenomenon except a rainbow.

Awards for 1948 will be notified in *Weather*, May 1949.

RULES

(1) The submission must be in English and, if possible, typed. All drawings and diagrams should be in lead pencil on smooth paper 10" × 8".

(2) All photographs to be as sharp and as full of gradation as possible, with good contrast. Prints should be glossy and in black and white.

(3) Copyright of submissions gaining prizes to become the property of the Society.

(4) Name and Address to be given in block letters on each entry.

(5) The Society will endeavour to return all unsuccessful work provided a stamped addressed envelope of suitable size is sent.

(6) The Society's decision shall be final and no correspondence can be entertained.

(7) Entries must be addressed to : "Sir Napier Shaw " Competition—
Royal Meteorological Society, 49 Cromwell Road, London, S.W.7.

(8) Latest receiving date for the 1949 competition :
Home entrants—September 30, 1949 ; Overseas entrants—October 15, 1949.

(9) Submission of an entry will be deemed to indicate acceptance of these rules. There are no entrance fees and no application forms, but entrants for the Senior Section must include with their entry a certificate that they are not professional meteorologists.

(10) Prizes will be withheld if a sufficiently high standard is not attained.

LETTERS TO THE EDITORS

Kew Radio-Sonde Recorder

The standard practice with the Kew radio-sonde (see *Weather*, Vol. 1., No.1) is to measure the audio frequency of the signal by comparison with the output of a resistance-capacity oscillator whose frequency can be made to match the radio-sonde frequency by manual control. This method is capable of giving great accuracy with a skilled operator, but, in unskilled hands, considerable errors will arise and readings may sometimes even be missed because of the very short time—about 5 seconds - available for making and recording each reading. It was considered by the Dutch Meteorological Service that an automatic recorder might be better for routine use ; the accuracy would perhaps not be so good as with a skilled operator but would be much better than with an untrained operator. A recorder is normally used with the U.S. Weather Bureau radio-sonde but it covers the range 0-200 c/s as compared with the Kew radio-sonde's range 700-1000 c/s. It would be possible to alter the range of the U.S. recorder to 0-1000 c/s but then only part of the scale would be used and even with a very open scale the limiting accuracy would be only 1 or 2 c/s. To avoid this difficulty, a new device has been developed in Holland, whereby the radio-sonde frequency is compared with a constant frequency of 1000 c/s and the frequency-difference is recorded on a U.S. Weather Bureau recorder, adapted to cover the range 0-300 c/s. The accuracy of this combination is between 0.3 and 0.6 c/s which, we believe, is as good as that obtained in routine use by the original manual method. It is hoped that a full account of this device will be published elsewhere ; in the meantime, readers can obtain details from the Director, Koninklijk Nederlands Meteorologisch Instituut, De Bilt, Holland.

De Bilt, Holland. H. J. A. VESSEUR.

Daily Thunderstorm Chart

In view of the interest which has been taken in the publication of the Thunderstorm Chart for June 14, 1948, a further map has been prepared to show the areas and movements of the extensive storms in the North-West on July 31, 1948. The travels of the various parts of the thunderstorm structure are shown by means of hourly isochrones, and the changes in the movement which take place in the neighbourhood of the Mersey Estuary are of special interest.

Analysis follows the lines of the work on the storms of July 15, 1937 (*British Thunderstorms*, Vol. 2, p. 137) but areas of damage by lightning are now shown for the first time. The data give a useful indication of the variation in general intensity within the districts in which the storm was overhead.

The present chart covers England and Wales on the scale of 10 miles to the inch. It measures about 40″ × 40″ and is a direct photoprint from the original plottings. Copies may be obtained from the Thunderstorm Census Organization, price 6*s*. each.

Langley Terrace,
Oakes, Huddersfield. S. M. BOWER.

Man-made Cirrus?

In his account under the above heading in *Weather*, August 1948, R. M. Poulter wonders whether the aircraft which was the cause of the phenomenon he there describes was a jet aircraft. Whatever the answer was in this case, it is certain that aircraft using propellers can set up the type of trail he describes.

In the summer of 1941 I was lucky enough to see such a trail in formation. Although my memory is a bit hazy, due to the lapse of time, I think the order of events was as follows: the aircraft flew in the layer of altocumulus—which was very thin : immediately on the passage of the aircraft the clear lane started and in the centre of this, behind the aircraft, the condensation trail commenced. This appeared normal at first but gradually transformed into a flat band of feathery cirrus with a sort of herring-bone pattern. This band did not fill the whole of the clear lane. As time went on (the clouds were drifting only very slowly, so that the trail was visible for some considerable time) the " cirrus " showed the phenomenon of iridescence to a very high degree. The trail was much curved and the loops were spread over a large part of the sky. The extent, the brightness and the number of shades of colour far surpassed any natural display of iridescent clouds I have seen.

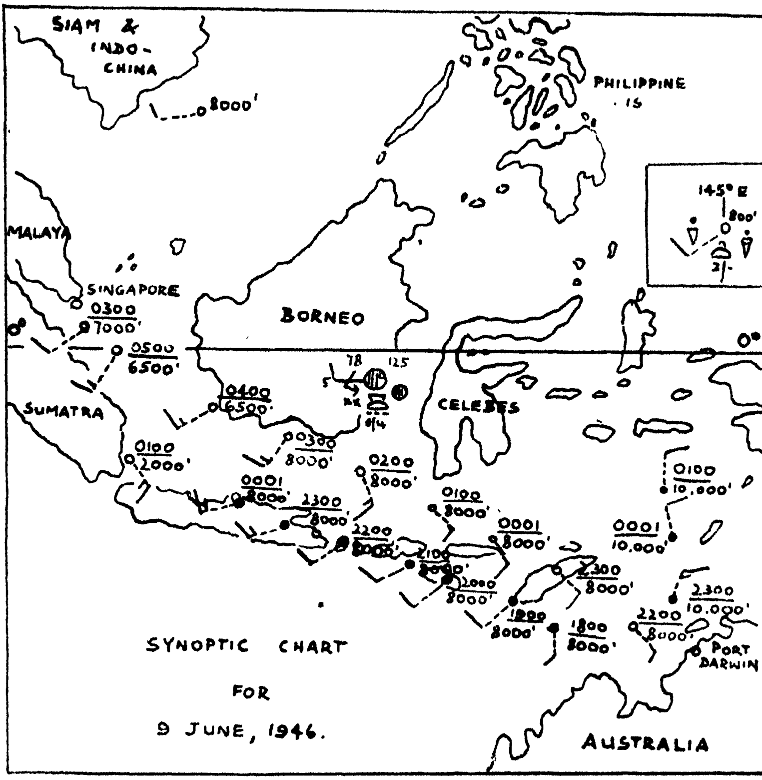
I understand from Wg. Cdr. Poulter that the trails on June 24, 1948 showed no iridescence.

Meteorological Office,
Dunstable C. J. M. AANENSEN

Unusual Westerly Winds below the Equator

A recent remark by Cdr. Burgess at the May meeting of the Royal Meteorological Society (*Weather*, June 1948, p. 181) on the puzzling frequency of westerly winds close southward of the equator, in the eastern half of the Indian Ocean and northward of Australia, prompts me to add a few comments and, incidentally, to pose a problem which may interest extra-tropical forecasters who have not had the fortune (or misfortune) to encounter this phenomenon. The situation referred to by Cdr. Burgess is briefly as follows :

At the beginning of the southern winter (i.e. in May and June) the great high-pressure cells of the southern hemisphere are swinging northward, and the SE. Trade blows, at the surface, right across the Java Sea, gradually becoming a southerly and then a south-westerly wind as it crosses the equator and progresses north-eastward over Borneo and the South China Sea. In the lower levels this south-easterly stream is quite strong but, as one goes aloft, a remarkable change takes place : the SE. stream gives way to *westerly* winds as far south as 10° below the equator. The accompanying chart of upper winds over the East Indies shows the pecu-



liar nature of the problem :] the lower level winds to S. and SW. of Borneo are probably SW. Monsoon ; the SE. winds from Darien to the Celebes SE. Trade. What, then, are the south-westerly winds (at the same level) only a little to the south, below Java, Bali, Timor, etc. ? The Rev. C. E. Deppermann, in his *Upper-Air Circulation over the Philippines and Adjacent Regions*, says :

" From the two kilometer level upward, from 20° N. latitude to the equator, and even for 10° below the equator, we now often have a strong sweep of almost directly west winds. Even though the SW Monsoon of India at the surface seems such a mighty stream that we can easily imagine it sweeping all before it even up to five kilometers altitude, still certain arguments make us hesitate to accept such a conclusion. These are : (*a*) Although the South Pacific Trade (i.e the SE. Trade) on the surface map from New Guinea to Sumatra seems to dominate everything north of the equator in the Borneo-China Sea area, yet even at the two kilometer level there is usually the onset of a direct west wind around the equator. This west wind has all the marks of a different stream entirely because of a very abrupt discontinuity of wind direction from the straight east winds of undiverted South Pacific

Trade just below it in latitude. (*b*) This direct west wind is found even *below* the equator, where the tendency of the Coriolis force is to bend an air stream to the left and not to the right. We cannot now appeal to the heat 'low' in North-West Australia, for that has vanished; neither can we have recourse to temperate zone westerlies of the southern hemisphere, since they are cut off from our region by strong undiverted South Pacific Trade easterlies."

Deppermann considers many other arguments in favour of classifying the strange westerlies as SW. Monsoon, but comes to the conclusion that the data are too incomplete to be dogmatic about the question, and he finally designates them "Indian Westerlies", leaving their ultimate origin undecided.

I would say that no unusually bad weather was encountered by the aircraft which reported the winds shown on the chart. The Intertropical Front was, of course, at that time somewhere through the Philippines, and a typhoon was developing near 145° E. (see inset aircraft report).

Norton, Malton, Yorks. C. A. Wood

The Border Floods

Your correspondents in Scotland desire some explanation as to why the disastrously heavy rainstorms of August 12 which, over the eastern Scottish borderland, caused such devastation, arrived with so little warning.

Having practised the art of forecasting as an amateur for a good many years, perhaps I may venture an explanation based on the salient points derived from a study of the charts in the Air Ministry's *Daily Weather Report*.

For four days from August 8 most of Scotland was covered by a cold air mass brought south by a rapidly moving cold front associated with a depression over S. Scandinavia. It seems unlikely that there was much surface heating during this time, since there was very considerable cloud cover throughout. Out on the Atlantic shallow "lows" were moving eastwards, the leading one, with which we are concerned, containing in its warm sector air which appears to have originated in the Gulf Stream region around Bermuda as far back as August 6. Some 500 miles W. of Ireland the trough, in association with the "low", appears to have commenced to occlude and the whole system was moving ESE. Upon reaching St. George's Channel at 01.00 h. on the 11th, the centre (1,008 mb.) and the accompanying occlusion seem to have changed direction by moving ENE., and during the 11th a lowering of pressure at the centre from 1,008 mb. to 1,000 mb. over E. Anglia at 01.00 hrs. on the 12th occurred, while the occlusion, then lying across Southern Holland, the southern North Sea and Northern England, was shown to have become almost stationary. In view of the origin of the warm air which ascended at this occlusion and the fact that the upper air temperature over this region must have been very much lower in relation to it, conditions were excellent for the formation of thick unstable upper cloud yielding copious thundery rainfall As pointed out by one of your correspondents, there seems to have been barely 0·2 inch (7 mb.) fall in the pressure over SE. Scotland, but pressure was falling much more rapidly over the Atlantic seaboard and somewhat later over the Midlands and S. England. This seems to have been due to another incoming Atlantic trough moving ESE. and merging the circulation of a primary over Iceland with that of the small secondary, the latter subsequently becoming the primary This merging of the two systems was becoming quite apparent by 06 00 hrs. on the 11th, and it accounts, in my opinion, for the temporary "static" character of the occlusion over N. England and S. Scotland throughout much of the 12th.

The Air Ministry's forecast for August 12 said: ". There will be periods of rain or thundery showers in NE. England and SE. Scotland." Perhaps the single adjective "prolonged" in relation to the periods of rain would have just met the case.

One final point. I think the above case proves yet again that the magnitude of a pressure change is by no means always indicative of the intensity of the weather following it. If it were so, would not every possessor of a barometer be a first-rate weather prophet?

Eastwood, Essex S. R. Giddings

In the September issue of *Weather*, *Vol.* 3, *No.* 9, under the heading "The Border Floods," correspondence appeared, commenting upon the remarkable conditions which then existed in S.E. Scotland at the opening of the grouse season on August 12. In his opening paragraph one writer asked, "Has any explanation been given for the latest forecasting 'Flop' regarding the floods centred on Berwick . . ."

It will interest readers to know, that the conclusion reached by the Meteorological Office is, (*vide The Meteorological Magazine* for January, 1949), that, "The phenomenal rainfall was due to an exceptional combination of factors and cannot be adequately explained even after the event." So writes Mr. C. K. M. Douglas in an article, after giving a detailed analysis of the weather charts during the period of the rainstorm.

Dr. J. Glasspoole also, in an article, has pointed out that almost 400 million tons of water—or approximately one quarter of the whole year's rainfall—fell in the Tweed Valley in 24 hours!

From "The Weather of August 1948," page 281 of *Weather*, it is interesting to recall that, "rain fell so heavily and for so long that night," that, "6.21 inches in the 24 hours to 8 a.m. 13th at Floors Castle near Kelso" was registered. Comparisons are odious sometimes, but, for those who may be interested in records, the record 24 hour rainfall for the British Isles is 9.56 inches recorded at Bruton, Somerset, on June 28, 1917. A raincloud burst over the Quantock Hills, and the deluge was released over a comparatively small area.

Melrose, Roxburghshire — G. BAIN ROSS, M.A.

What occurred during the Transfiguration?

During lighter moments it is interesting to pick out meteorological happenings recorded in the Bible, and on the Feast of the Transfiguration last year I pondered over what actually occurred. The Transfiguration probably occurred on Mount Hermon, at a time when it was snow-capped and thickly enveloped in mist. If a small but complete break occurred in the mist and Jesus was wearing white clothing, the sudden sunlight, particularly that reflected from the snow, falling on the white material would appear brilliant, particularly in contrast to the previous gloom. Under such circumstances the disciples could have seen Brocken Spectres of themselves, each with a coloured glory round the head. These could provide an explanation of the appearance of Moses and Elias. There were three disciples, and one would have expected to hear of three of the patriarchs appearing, but maybe one disciple was standing in front of rocks in such a position that he could cast no shadow on the mist. The phenomenon ends in the way one would expect, by the agency of a cloud, i.e. the mist thickened again.

Wrexham — S. E. ASHMORE

Editorial Note—Mr. Ashmore can select the weather conditions to fit his requirements, but he seems to be asking rather much of a Brocken Spectre Moses and Elias are reported not only to have talked but to have had a knowledge of the future!

Marvellous Meteorology

I have pleasure in relating
Of a Science fascinating
Which is worthy of debating
Though slightly irritating—
In other words it's MET.

From a study emanating
It presents the world rotating
On it's axis—innovating,
No plainer facts relating—
It's pure and simply MET.

It's a science entertaining,
No bit of use complaining
Of an interest slowly waning
In a subject so retaining—
It simply must be MET.

Of an outlook philosophic
On a matter Isentropic,
With a wind that's Geostrophic,
A most amazing topic—
You find it all in MET.

In a subject so mathematical,
Of an Art that's Anabatical,
An effort problematical,
Or even half fanatical,
Symbolical of MET.

With a very deep depression
We can cause a heap-impression
And an ultimate confession
With a theory of repression—
Remember that it's MET.

We are often driven frantic
By a cyclone in Atlantic
Which approaches so gigantic,
And far from the romantic,
Which is all to do with MET.

The synoptic situation
Based on divers information
Is considered in relation
To pressure palpitation,
So marvellous this MET.

We look at lines of latitude
With deep and honest gratitude.
A true fraternal attitude,
Or is it just plain platitude,
This sentimental MET.

With a thousand illustrations
We can satisfy the nations
That the weather indications
Are against all demonstrations—
We leave it all to MET.

To prove that front occlusion
Isn't mystical illusion
We apply the thermal fusion
To draw the main conclusion
That it's all to do with MET.

And now this chant is ended
We hope you're not offended.
There is no harm intended
Just a point of view defended—
And that point of view is MET.

Firestone University, Pretoria. — A. G. SECCOMBE

Cobwebs or Flying Saucers?

By a curious coincidence, I had just finished reading the letter to the Editors in the September issue of *Weather*, entitled "Cobwebs in the Rigging", when a colleague of mine started to describe a phenomenon he had observed the day before and which he had taken to be an actual manifestation of the illusive "Flying Saucers" which raised so much excitement some time ago. After talking the matter over we were both satisfied that what he had seen was a particularly fine example of a large mass of "cobwebs" described in the very interesting letter from Messrs Ovey and Browning.

As his description may be of interest to your readers, coming so shortly after the above letter, I pass it on to you for publication.

"*Sunday, September* 26, 1948. *Port Hope, Ontario.* This day was warm and the sky cloudless. We had had dinner in the garden and I was lying on my back on the lawn, my head just in the shade of the house, when I was startled to see an object resembling a star moving rapidly across the sky. The time was 2 o'clock, Eastern Standard Time.

At first it was easy to imagine that recent reports of 'Flying Saucers' had not been exaggerated.

More of these objects came sailing into view over the ridge of house, only to disappear when nearly overhead. With field glasses I was able to see that each was approximately spherical, the centre being rather brighter than the edges. The glasses also showed quite a number at such heights that they were invisible to the naked eye.

With only a gull flying in the sky for comparison, I should estimate the elevation of the lower objects to be about 300 ft. and the higher ones 2,000 ft., the size was about one oot in diameter and the speed about 50 m.p.h., in a direction SW. to NE.

Also visible every now and then were long threads, apparently from spiders. Some of these were seen to reflect the light over a length of three or four yards, but any one piece may of course have been longer. Each was more or less horizontal, moving at right angles to its length. In one case an elongated tangled mass of these gave the appearance of a frayed silken cord. These threads appeared only in the lower levels.

It is reasonably certain that these objects were balls of spiders' threads, possibly with thistledown entangled in them, but the way in which they caught the rays of the sun and shone so brightly was very striking —P. L. LEWIS."

This may really be the cause of the "Flying Saucer" scare. Port Hope is some 60 miles east of Toronto and a SW. wind would waft these webs from the Middle West, where the saucers were so often reported The play of light would also explain why aeroplanes sent up to investigate could never find them. No one else seems to have seen them on this occasion, but perhaps Mr Lewis was the only one to be taking horizontal, post-prandial repose at that time

Trinity College School,
Port Hope, Ontario

P. R. BISHOP

[We have been asked to correct a printers' error in the original letter by C. D. Ovey and E. Browning, referred to above The name of the family of spiders there mentioned should have been *Linyphiidae* EDITORS]

PHOTOGRAPHIC SKIES*

121 pages.
16 full page plates.

By David Charles, F.R.P.S.
Iliffe & Sons, Ltd.,
London, 1948, 5/- net.

The object of this book is to instruct the keen photographer how to obtain good cloud photographs and how to superimpose them on pictures with an uninteresting area of blank sky. The author has developed a new technique of printing-in suitable sky backgrounds, the D.C.S. method, which overcomes most of the difficulties of earlier procedures ; one great advantage is that it produces a negative from which any number of prints and enlargements can be made. This new technique is described in detail and the photographer who has this book in his possession should be able to put into pictures taken on all those cloudless or nearly cloudless days just those skies which he wished had been present.

Readers of *Weather* will probably turn first to the chapter entitled *Taking Sky Negatives*, in which useful advice is given about the type of film to use, calculating the exposure and the application of filters. The author has found by personal experience that there is little to justify the common belief that one can tell by examining a cloud photograph whether the sun was shining or not, and, if it was, then in what direction. If he is correct, the problem of superimposing convincing cloud backgrounds is obviously greatly simplified. The examples given in the book are sufficient to illustrate the good results that can be achieved by the D.C.S. method.

O.M.A.

* Review

THE NIGHT SKY *

96 pages
30 illustrations.

By J. G. Porter, Ph.D.
Winchester Publications Ltd.
London, 1948. *5s. 0d.*

For encouraging young folk who show signs of interest in the stars and planets, and also for teaching those of riper years to "find their way about the constellations", this little book by the President of the British Astronomical Association could hardly be bettered. It is based on a deservedly popular series of monthly talks broadcast by the author from London in 1946-47. But the book has a great advantage over the talks in that it is illustrated by an attractive set of line drawings—the work of Eileen C. M. Phillips. With the aid of these and Dr. Porter's lucid, friendly guidance any neophyte who will spend a few clear evenings in the open air each month should soon be able to memorise all the main features of our northern skies. Though the appeal of astronomy to the general public has certainly increased in recent years, it still seems to be considered less of a disgrace for an educated man or woman to be unfamiliar with the outlines of Orion or the whereabouts of Cassiopeia than not to know the difference between an oak and a beech or between a crow and a blackbird. Why ? Dr. Porter's easy conversational style is well suited to his purpose of combating this ignorance. His material has the further merits of avoiding sensationalism and of being plentifully leavened with humour. A couplet of Hilaire Belloc's which Dr. Porter quotes as the only fit motto for a sundial ought to be widely known :

I am a sundial, and I make a botch
Of what is done far better by a watch.

In the course of 12 chapters (one for each month, beginning with October) almost every known type of celestial object receives brief description. Such popular misconceptions as that a comet streaks across the sky like a rocket and that meteors are true stars falling from the firmament are duly corrected. The author has compressed an astonishing amount of information into less than 100 pages of fairly large type.

Here and there the astronomer will find departures from strict accuracy, some of them evidently due either to the need of verbal economy in so small a work or to the fact that the original broadcast talks were designed to deal with the aspect of the sky in one particular year. A statement on p.14 that "one can see only six stars" in the Pleiades requires qualification : many keen eyes can make out 8 or 10, and Kepler (in pre-telescopic days) could discern 14. On pp. 38-39, Dr. Porter maintains that the lunar eclipse described by Rider Haggard in the second edition of *King Solomon's Mines* was impossibly dark. Yet Humboldt records that in the total eclipse of June 10, 1816 the moon became invisible from London, even with a telescope. This rare phenomenon may have been due to the charging of the earth's atmosphere with enormous quantities of dust ejected in 1815 by the volcano Tomboro (Sumbawa) during

* Review

one of the greatest eruptions of the 19th century. Answering his one question, "Is ours the only inhabited planet?" Dr. Porter writes (p. 56) "one would have to be very selfish to believe that our sun is the only one among these millions of stars that can support life." To the reviewer's way of thinking, it might as well be imagined by a group of parasites infesting a single apple on a tree in the midst of a vast orchard that no form of life existed on any other apple, whether on their own tree, in the surrounding orchard, or in orchards beyond their ken.

E. L. HAWKE

THE SECRET LAND

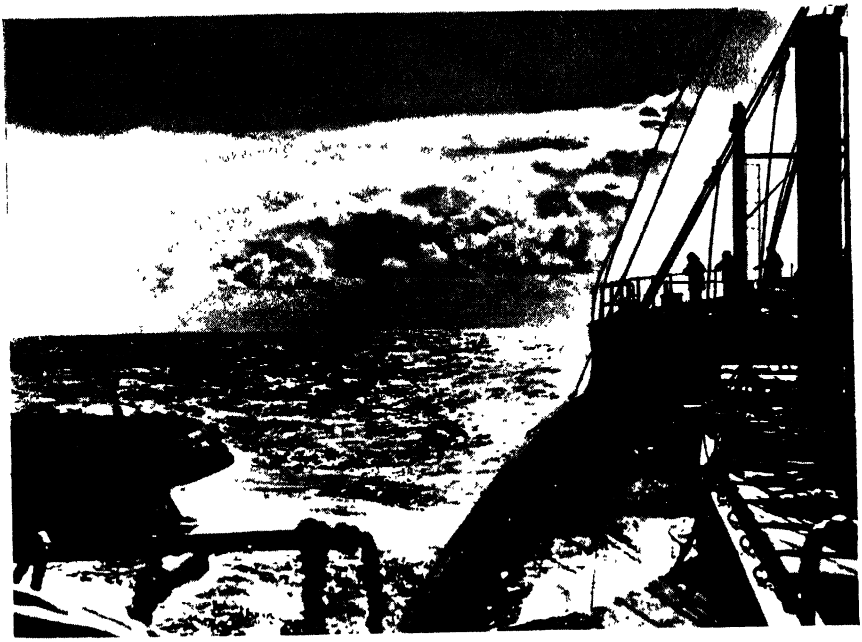
Many who have read Admiral Byrds' own account of Operation Highjump in the October 1947 issue of the *National Geographical Magazine* must have wondered if they would ever have the opportunity of seeing some of the films taken during this spectacular expedition to Antarctica. A selection of the films has now been issued under the title *The Secret Land*, with a running commentary by Robert Montgomery, Robert Taylor and Van Heflin. The pictures reproduced in Plate III and on the cover can hardly give any impression of the magnificent photography in the film; the technicolour material has withstood remarkably well the extremely low temperatures experienced.

Unlike many documentary films, this one includes some very dramatic scenes, such as the rescue of six airmen whose 'plane had crashed in snow-covered mountains, Admiral Byrd's return flight from the Pole when he had serious engine trouble, and the rescue of one of the ship's captains from the icy sea after the rope by which he was being transferred from one ship to another had suddenly snapped. Even without incidents, the film would be more thrilling than many non-documentary "thrillers". To see the rugged mountains and glaciers of the interior of Antarctica is to be transported to another world; the chief complaint is that these shots of a land that so few can ever see in person are tantalizingly brief.

Comparison with *Scott of the Antarctic** is inevitable: it is a fortunate coincidence that these two films can be seen shortly after each other. The Scott film epitomizes the individual struggle of a few men against the might of nature, while *The Secret Land* shows how much can be accomplished by 4,000 men equipped with the latest machines and instruments. After seeing the Beardmore glacier and other landmarks of the Scott route to the Pole from the air, it seems more incredible than ever that anybody could traverse such country on foot. The two films seem to reflect different philosophies of life, the one in which the individual personality is all important and the other in which the achievements of highly organized men and machines are paramount. Perhaps, sometime, a mass assault on Mount Everest will result in a film which can be similarly compared with *The Epic of Mount Everest*, a film that remains fresh in the memory after more years than we care to reckon.

O.M.A.

* An article by Mr. A. J. Drummond on "Scott of the Antarctic" will appear in *Weather* of next month.



Scenes from the film *The Secret Land*, a record of Admiral Byrd's recent expedition to the Antarctic.

By courtesy of] [*Metro-Goldwyn-Mayer*

PLATE III

Meteorological instrument enclosure at Rothamsted Experimental Station. In the immediate foreground is the standard raingauge, while the square hole on the left contains a M.O. evaporation tank Beyond the tank in the same line are the 1/1000 acre raingauge and three bare soil draingauges. To the right of these is a pit, around which are the soil cylinders used for evaporation studies.

PLATE IV

ROYAL METEOROLOGICAL SOCIETY NEWS

METEOROLOGY IN AGRICULTURE

At a crowded meeting of the Society on March 16, new faces appeared, new voices were heard, and new ideas were vigorously put forward on a subject that is dear to every English heart—the growing of food.

The meeting opened on orthodox lines. Dr. H. L. Penman began by classifying agricultural meteorology under three heads, physical, biological, and statistical. As an example of the physical, he described calculations he had made, from the energy and water balance of the atmosphere, of the rate of loss of water from the soil; his final expression depended only upon measurable quantities such as the rate of evaporation from an open water surface. He had then tested the calculations on a large farm, on land fitted with water sprays for the irrigation of sugar beet. In comparison with unirrigated land and with irrigations left entirely to the farmer's discretion, Dr. Penman produced the best yield of sugar beet, but the differences were not significant—the test was made in 1948 which was a nearly perfect growing season. He was hopeful, but only with the optimism of "an engineer who has built a bridge to take a 50-ton load, and has found he can safely walk across it".

Dr. Broadbent, also from Rothamsted Experimental Station, described some of the difficulties in raising a perfect potato crop. He gave a list of the effects of heat, cold, and rain, and mentioned that every day's delay in planting, after a certain date, reduces the crop by about 2 per cent. He was mainly concerned with the virus diseases, leaf roll and rugose mosaic. These were spread by aphids, which were highly dependent on weather, and weather also affected the susceptibility of the plants. Aphids multiply enormously at 18°C. or over, and in the south it is impossible to check the infection of tubers each season. Seed potatoes must therefore be grown in the cooler districts where "roguing" (i.e. the removal of damaged plants) is an effective way of attacking the virus before it can be spread by winged aphids bred from the wingless kind which can survive the winter. The remarkable life cycle of the aphid is an important factor, and also the fact that winged aphids cannot fly "voluntarily" in winds exceeding 2 mi./hr.

On being thrown open to discussion, the meeting was immediately electrified by Mrs. Meiklejohn, who demanded a special meteorological service for farmers. She said farmers could make valuable use of very simple forecasts of the weather 12 or 18 hours ahead in their own immediate neighbourhood. The exact times of rain and high wind were the main items of interest. Why could not every farmer pay a small fee and ring up the nearest of a network of weather-information offices? Other speakers supported this. Professor Dudley Stamp, Chief Adviser in Rural Land Use to the Ministry of Agriculture, went further and asked for systematic observations of microclimate. He emphasized the need for temperatures within the crop, and called the Stevenson Screen "the most damnable thing ever invented". For a while, this highly respectable piece of furniture became an Aunt Sally—Mr. E. Gold, in the chair, thought

it useful for measuring temperatures at the height of a golfer's chin, and Mr. Hogg thought it might do for growing things in.

However, the fair-ground atmosphere vanished as suddenly as it came, and Mr. Gloyne stated the aims of the Meteoroligical Office branch for Agricultural Meteorology. These were (1) defining local variations in climate, and (2) for any given climate, finding the best procedure in such operations as haymaking for which there are different ways in different weathers. He thought forecasting relatively unimportant ; but in any case the forecaster would have to know a great deal about farming techniques. There was, however, a tremendous interest in agricultural meteorology, and we would do well to follow it up.

SCOTTISH CENTRE

A meeting was held in the Department of Natural Philosophy, Edinburgh University, at 7.30 p.m. on Friday, March 11, Mr. Paton presiding.

Mr. W. G. Gray, M.A., B.Sc., a Fellow of the Society, read a paper on "Meteorological factors determining the development of plant pests and diseases". He discussed the intimate relationship between weather and both the development of the pests and the growth and resistance of the plants. Often, when conditions would be regarded by most as ideal for the promotion of steady, if not rapid growth, diseases—for example mildew, brown heart and hollow heart—were rampant.

He regarded it as doubtful if, in this matter, either the agriculturist or horticulturist would benefit from accurate long-range weather forecasts (in which Mr. Gray himself was specially interested), for the enemies, the pests and diseases, would be there in any case. He suggested that farmers and gardeners might be enlisted to take a more active part in providing for the research worker information concerning the incidence of pests and diseases in different soils.

In the ensuing discussion, Dr. Foister of the East Craigs Research Station took a prominent part, pointing out that much had already been achieved in this matter and agreeing with Mr. Gray that there was ample room for further work in which the agricultural research worker and meteorologist might cooperate.

FORTHCOMING MEETINGS

On Wednesday, April 20 at 5.0 p.m., Dr. G. E. R. Deacon, F.R.S., will deliver the Symons Memorial Lecture at 49, Cromwell Road, South Kensington. His subject will be "Waves and Swell".

On Tuesday, April 26 at Birmingham University, Mr. G. H. Thompson will give a lecture to the Midland Centre on "An account of some recent hygrometrical research".

On Thursday, May 5 at 6.0 p.m., at the Science Museum Lecture Theatre, Exhibition Road, South Kensington, Mr. E. Gold, F.R.S., will give the last of the present series of popular lectures. His subject is "Meteorology in the first World War". Sir Charles Normand will be in the Chair.

On Thursday, June 9 at 5.30 p.m., at Edinburgh University, Sir Nelson K. Johnson, K.C.B., D.Sc., will address the Scottish Centre on "The organization and work of the Meteorological Office".

REPORTS OF POPULAR LECTURES

On March 3, Professor Gordon Manley's lecture on " British climatic fluctuations since Queen Elizabeth's day " was much enjoyed by an appreciative audience at the Science Museum Lecture Theatre. Both they and others who missed it will like to know that Professor Manley has undertaken to write it as an article for *Weather*. The popular lecture by Professor G. M. B. Dobson on April 6, on " Some solar and terrestrial relationships ", and that by Mr. E. Gold, announced above, will also be reported in *Weather*. A report of Sir Nelson Johnson's lecture on February 10, on " Some international aspects of meteorology", will appear next month.

METEOROLOGICAL OFFICE DISCUSSION

The Monday Evening Discussion, held in the Small Physics Lecture Room of the Imperial College of Science at 3.30 p.m. on February 28 was attended by an unusually large audience eager to discuss " Experiments in Four-Day Forecasting ".

The opening speaker, Dr. A. G. Forsdyke gave a *resumé* of the work on extended-range forecasting carried out in Germany by Baur, in this country by Brooks and in the U.S.A. by Namias and others. The method now under trial at the Forecasting Research Division, which formed the basis of the subsequent discussion, was not statistical in character like that of Baur, nor was it dependent on the concept of the five day mean, so much used in America. It was simply a logical extension of short-range forecasting techniques, using thickness patterns, based on the theoretical ideas recently advanced by Sutcliffe. From the nature of this approach it was apparent that no startling advances were likely and that small gains could be achieved only by extensive preliminary studies.

Dr. Forsdyke illustrated his contribution by some interesting examples of recent successes and failures in four day forecasts for the British Isles. A statistical summary of results to date, though necessarily of a rough and arbitrary character, would have been of value in assisting a rather divided audience to form a first opinion of the value of the method.

T. H. K.

THE DISCOVERY COMMITTEE

Meteorologists are well aware of the necessity for close association with oceanographers and will rejoice with them over the recognition which has now been accorded to them.

The Discovery Committee which takes its name from Captain Scott's ship of Antarctic fame, was constituted by the Colonial Office in 1923 for research into the economic resources of the Falkland Island Dependencies. Since whaling is almost these islands' only industry, the Discovery Committee's primary function was the study of the biology of whales, the distribution of their food and hence the temperature, salinity and movement of water in the Antarctic.

The committee has now been transferred to the Admiralty and before long will be reorganized as part of a National Institute of Oceanography, no longer confining its interests to south polar regions.

THE WEATHER OF MARCH 1949

VARIABLE BUT DRY

March last month was again dry over most of Britain and Ireland, several localities receiving less than 50% of the normal ; over much of South and East England the deficiency over the last seven months is 30% or more and it is arousing some consternation amongst those responsible for water supply in Eastern Counties where this figure represents nearly five inches. Pressure was again unusually high but temperature was generally a little below normal.

The month opened with an intense depression passing south-eastwards over the North Sea, Denmark and Northern Germany accompanied by destructive gales. Squalls of 80 m.p.h. or more were recorded at Amsterdam and Yarmouth, and of over 70 m.p.h. at other places. Damage and injuries were caused by falling trees and chimneys, and by seas being blown over promenades. Moreover, the strong northerly winds caused unusually high tides in the southern part of the North Sea, and a Boston church bell was rung to warn residents of the highest tide since 1810. Flooding occurred in Norfolk, Suffolk and Essex while there was considerable anxiety during the afternoon in London until the tide began to fall. When the Thames was at its highest, H M. Ships *President* and *Chrysanthemum*, lying alongside the Victoria Embankment, were riding well above the road level while the terrace of the House of Commons was under water. Heavy snowfalls accompanied by gales in Germany interrupted the Air lift to Berlin, and many casualties were caused in bombed cities where war-damaged houses and other buildings collapsed. The same depression was associated with a surge of very cold air over Austria and Italy : the local inhabitants had not seen so much snow in Palermo for more than 50 years. On 6th, 20 degrees of frost was recorded at Florence.

A spell of south-easterly or easterly winds over Eastern England from about 4th to 11th was succeeded by a north-westerly type which became general by 13th. After a four-day spell of quiet anticyclonic weather, pressure became high again to the eastward and from 27th to the end of the month an easterly type was maintained.

In Canada there has been a surprising dissimilarity of weather While the western half of the country has been enduring a cold, hard winter, the eastern districts from Georgian Bay to Nova Scotia have had a mild one ; for Ontario it was very nearly the mildest winter on record.

Eastern parts of Central Australia experienced during March amounts of rainfall unprecedented since their habitation by white men, and an area of at least 50,000 square miles of cattle country was inundated.

	TEMPERATURE (°F.)				RAIN (mm.)*			SUNSHINE (hr.)		
	Long period Average Max.	Long period Average Min.	This month Extreme Max.	This month Extreme Min.	Month	Diff. from Av.	Last 12 months	Month	Diff. from Av.	Last 12 months
Kew Obsy.	50·3	37·5	63	28	23	—21	480	101	— 7	1550
Gorleston	47·3	37·1	54	30	40	— 4	504	95	—33	1679
Birmingham	48·5	36·1	60	27	40	— 9	761	95	— 5	1365
Falmouth	49·7	39·9	56	32	37	—51	858	115	—21	1734
Valentia	50·8	41·8	66	30	41	—75	1310	110	— 6	1248
Aldergrove	48·6	36·8	59	25	56	— 8	846	115	+ 4	1304
Holyhead	48·0	40·3	62	25	61	— 5	728	143	+18	1541
Tynemouth	46·9	37·7	62	30	40	— 6	538			
Renfrew	47·9	34·8	64	24	36	—35	1227	122	+28	1256
Aberdeen	46·5	36·1	59	27	61	+ 1	823	121	+ 1	1474
Stornoway	46·5	36·9	55	28	65	—37	1270	136	+27	1234

* 25 mm. - 1 inch (approx.) † The Lizard C.R.B.

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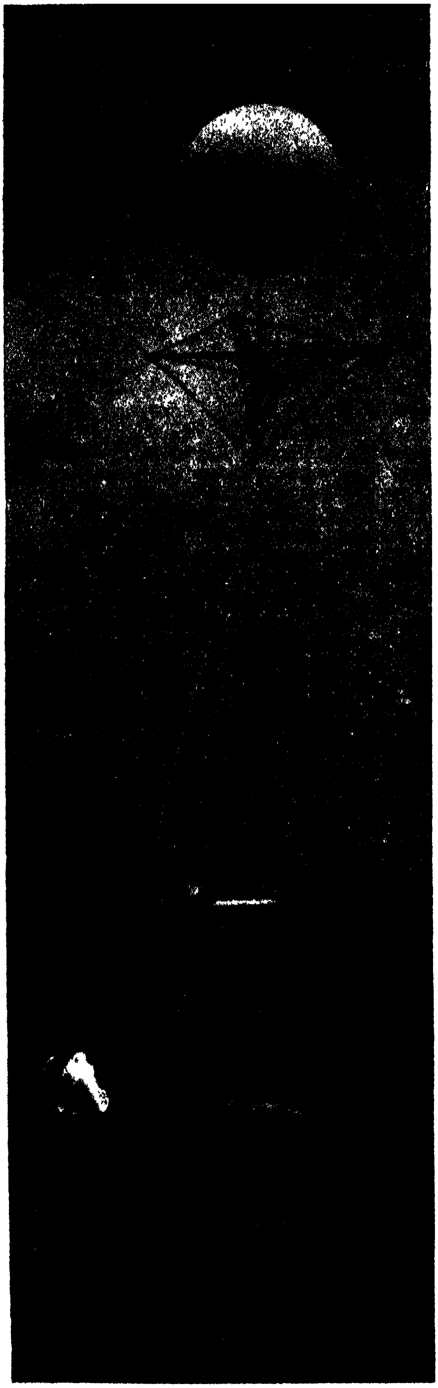


RELEASE OF RADAR REFLECTOR MARK IIB FROM U.S.A.N.R.L.

MAY 1949

WEATHER

Vol. IV No. 5

CONTENTS

EDITORIAL

The report of a lecture by Sir Nelson Johnson on page 148 shows how meteorology has become the concern of many different international organizations. Unlike some other international bodies, the meteorological organizations have produced many practical results, not the least important of which is the agreement to maintain a network of Ocean Weather Ship Stations in the North Atlantic. The future of this "Atlantic Pact" is at present being discussed at a conference in London of the International Civil Aviation Organization ; the costs of the scheme will undoubtedly be weighed against its benefits, some of which are intangible and difficult to assess. The very fine safety record achieved on the North Atlantic air-routes must be directly related to the introduction of these ships, and even if we cannot boast of an immediate improvement in the standard of forecasting—here we would remind readers of the methods of estimating the accuracy of forecasts suggested by Dr. A. R. Meetham in our issue of February 1947—the long term improvements are assured. Progress in forecasting tends to be slow, each small advance following the introduction of improved networks of observing stations, better communications, new instrumental aids or the application of new theory. Better routine forecasting techniques can only be developed as these improvements are digested, and so far nobody has discovered a pill to speed up the process.

It is to be hoped that the ICAO conference will decide to recommend the continuance of the North Atlantic scheme and the inauguration of similar schemes in other oceans as soon as practicable.

ATMOSPHERIC ELECTRICITY DURING THE LAST 50 YEARS

* By Sir George C. Simpson, F.R.S.

"It was clear that there must be some process acting in the atmosphere which replenished the negative charge on the ground and the positive charge in the upper atmosphere. The problem was to find this process."—*Remark made during lecture.*

Part II. Wilson's Theory of the Normal Electrical Field.

For many years the problem stated at the end of Part I of this article remained unsolved, and some of us became inclined to look for the origin of the negative charge on the ground to extra-terrestrial sources. In 1920 however C. T. R. Wilson put forward a new idea.

Wilson had been working on thunderstorms and had come to the conclusion that there is a great concentration of positive electricity at the top of a thundercloud and a great concentration of negative electricity at the bottom of the cloud. He also pointed out that the upper atmosphere is supposed to be highly conducting in what was then called the Heaviside layer. Now, Wilson said, in these circumstances the positive charge of the cloud will draw

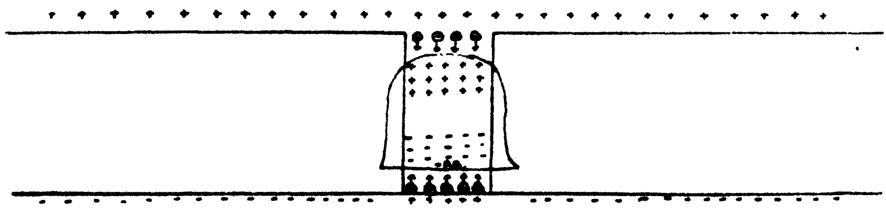


Fig. 2. Distribution of charges in a thundercloud, the Heaviside layer, and the ground.

negative ions out of the Heaviside layer leaving the layer itself positively charged, and the negative charge at the bottom of the cloud will draw positive electricity out of the ground, leaving the ground with a negative charge. The positive charge in the Heaviside layer and the negative charge on the ground being in electrical-conductors, can spread into all parts, not being bound to the charges in the precipitation area. The Heaviside layer extends over the whole globe, that is over the fine weather areas as well as the precipitation areas, and between the positive charge in the layer and the negative charge on the ground exists the normal positive potential gradient, and the source of the downcoming positive ions is the positive charge in the layer and the source of the upgoing negative ions is the earth, both sources drawing their electricity from the thunderstorm areas.

In 1920 when Wilson first put forward this idea it was very speculative, first because the Heaviside layer itself was only an hypothesis and no one knew its height or the electrical conductivity within it. Secondly in order for the

* From a Popular Lecture to the Royal Meteorological Society, on January 12, 1949, summarized by A. R. Meetham, D.Sc. Part I of this article appeared in *Weather* of April, 1949; Part III will appear in June, 1949.

return current in fine weather areas to be supplied in this way the upper clouds in a thunderstorm must on the average be charged positively ; and at that time there was much difference of opinion as to the polarity of thunderclouds. Wilson gave good reason to believe that the polarity was positive while I had given what I considered to be equally good reasons for believing that it was negative.

The next step forward came in 1925 when Appleton and Barnett made their classical experiments in which they not only confirmed the existence of the Heaviside layer, but also measured its height and determined its conductivity. The height and conductivity were both satisfactory from the point of view of Wilson's theory.

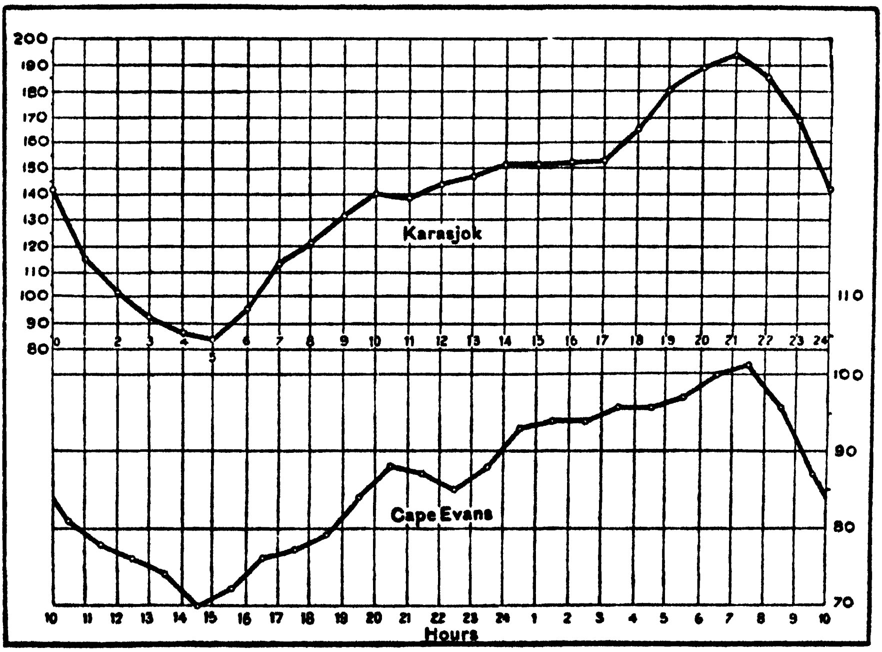


Fig. 3. Daily variation of potential gradient at two polar stations with very different longitudes plotted to G.M.T. (the local time is entered under each curve). Karasjok : Lat. 69°N., Long. 25½°E. Cape Evans : Lat. 77½°S., Long 166½ E.

THE DAILY VARIATION

In the meantime other observations had been made which had an important bearing on our problem. One of the chief characteristics of the potential gradient is that it has a marked daily variation which had been measured at many places, and it had been found that on the whole the results were similar : at most places there were two maxima and two minima ; the two minima were at 4 a.m. and near midday, while the two maxima were in late morning and early evening. It was therefore generally accepted that these daily variations were caused by local meteorological effects in the lower atmosphere and that they had no significance in the origin and maintenance

of the electrical field itself.

In 1923 Hoffman was discussing observations of the potential gradient in Spitzbergen and compared them with all the observations which he could find from other polar stations. He had records from seven stations, four in the Arctic and three in the Antarctic, and noticed that when the observations at the several stations were referred to local time, the hours at which the maximum and minimum occurred differed widely, but when he referred the daily variations at all the stations to universal time he found that all the principal maxima and minima agreed.

At practically the same time Mauchley published a preliminary note on the potential gradient observations made during the cruises of the "Carnegie" in 1915 to 1921. He found that at sea, well away from the land, the daily variations of the potential gradient in all oceans showed similar curves when plotted in universal time. Assuming that the daily variation of meteorological factors is at a minimum over the oceans and in polar regions, these observations show that in the absence of meteorological disturbances the potential gradient is not uniform throughout the day, but has a distinct daily variation which however affects all places on the earth in the same way and at the same absolute time.

This could be explained on Wilson's theory if the potential of the Heaviside layer underwent a daily variation, for the potential in this layer, because of its high electrical conductivity, must be the same in all places at the same time.

DAILY CYCLE OF THUNDERSTORMS

This is obviously an important support of the Wilson theory ; but it has only removed one of the difficulties from the ground to the upper atmosphere for now we have the problem why does the potential of the Heaviside layer change simultaneously over the whole world, so that it is at a minimum every day when a clock at Greenwich says 4 a.m., and a maximum when the same clock says 7 p.m. ?

The answer to this question appears to be that there are more active thunderstorms over the world as a whole at 19h. G.M.T. than at 4h. G.M.T. This suggestion was made independently by Appleton and Whipple, but it is to the latter that we owe the working out of the idea in detail.

Figure 4 shows the diagram prepared by C. E. P. Brooks indicating the distribution of thunderstorms over the world for an average year. There are three regions of chief activity (1) South-East Asia with the East Indies, (2) Africa, (3) America. Generally speaking, over land areas thunderstorms are at their maximum in the afternoon, and a minimum in the early hours of the morning. Now as the sun sweeps over each of these regions the maximum activity of the area south east of Asia will be reached at 16 hrs. local time, that is approximately 8h. G.M.T.; then about six hours later the maximum of the African area will occur, that is at 14h. G.M.T. Then after another six hours

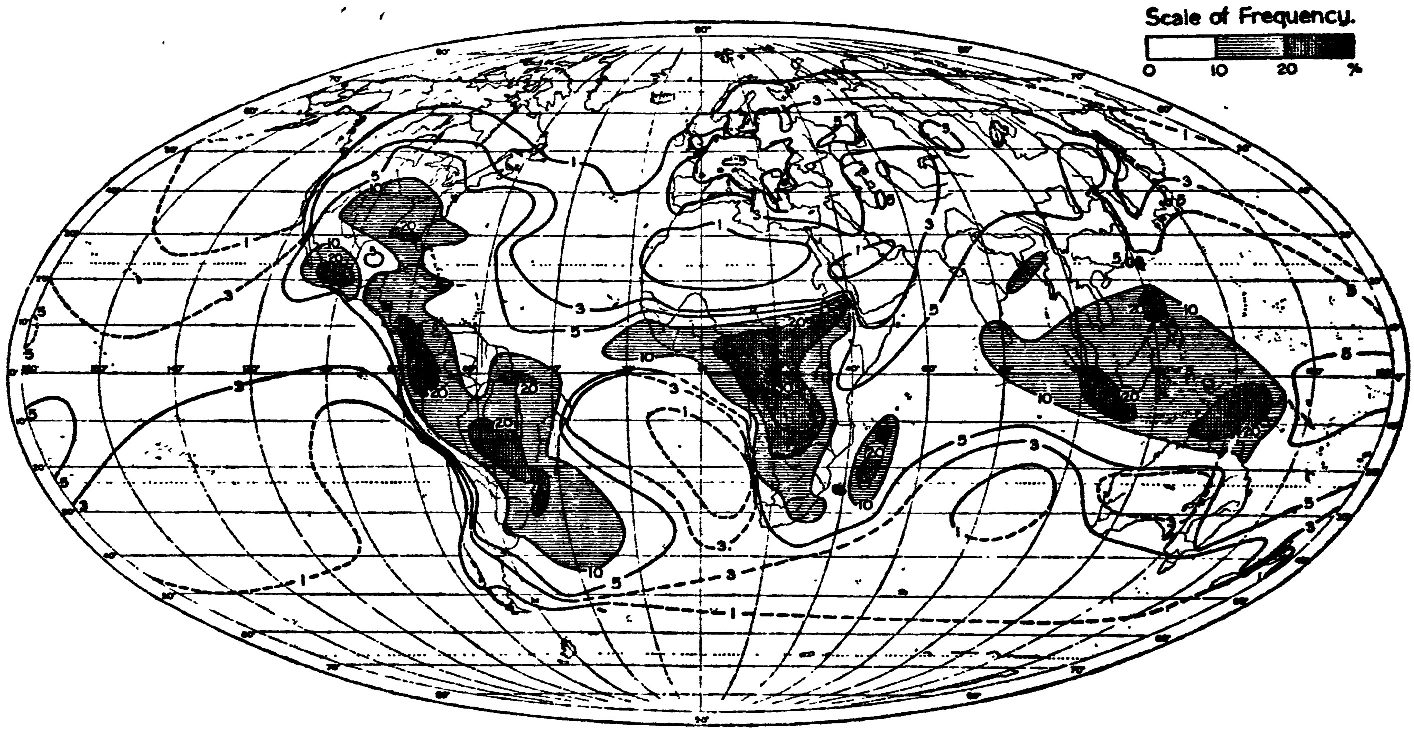


Fig. 4. Chart showing percentage of days with thunder heard during the year.

at 20h. G.M.T., the American area will be at its maximum. Proceeding along these lines and using the total activity in zones of longitude, Whipple produced the diagram of Figure 5, on which the average activity of four zones is represented separately, and also the sum of all four zones, that is of the world as a whole. Comparing the curve for the world as a whole with the curve for the potential gradient of "All Oceans " in the upper part of the diagram, it will be conceded that the agreement is surprisingly good.

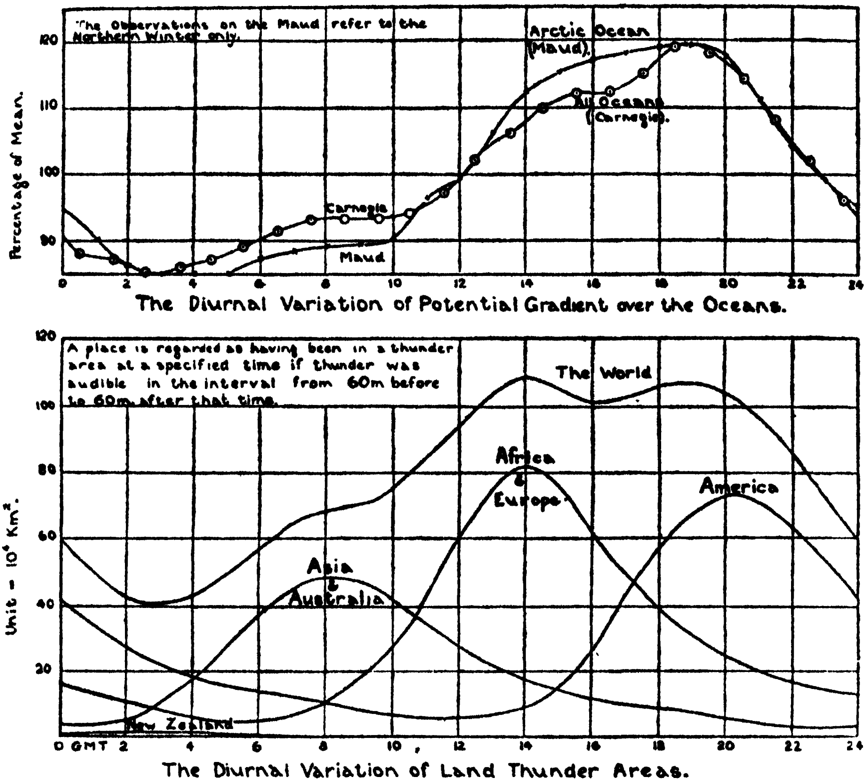


Fig. 5. (below) Daily variation of total thunderstorm activity.
(above) Daily variation of potential gradient, for comparison.

THE CHARGE ON A THUNDER CLOUD

This work was described before the Royal Meteorological Society by Dr. Whipple in 1929 and in concluding his paper he said that while the result strongly supported Wilson's theory there was still one snag. The whole theory depended on the charge in the upper part of the cloud being positive, while Simpson's theory of thunderstorms required that this charge should be negative. " But ", he continued " the problem is being attacked from many sides and it may be hoped that consistent explanations will be available in the near future ". It was however not until five years later that the series of observations was commenced at Kew Observatory under Dr. Whipple's charge which finally decided the question of the polarity of thunderclouds

Up to the time which we have now reached no observations had been possible of the actual distribution of the electricity in the thunder clouds. All the evidence we had came from a study of the changes of the electrical field at the ground on the passage of a lightning flash, and as I have already stated Wilson had drawn the conclusion that the top of a thunder cloud carried a positive charge, while from the same evidence I had concluded that the charge there was negative. In 1933 I pointed out to Dr. Whipple that if an instrument could be devised which would simply show the direction of the electrical force in various portions of the cloud it would give us a lot of valuable information.

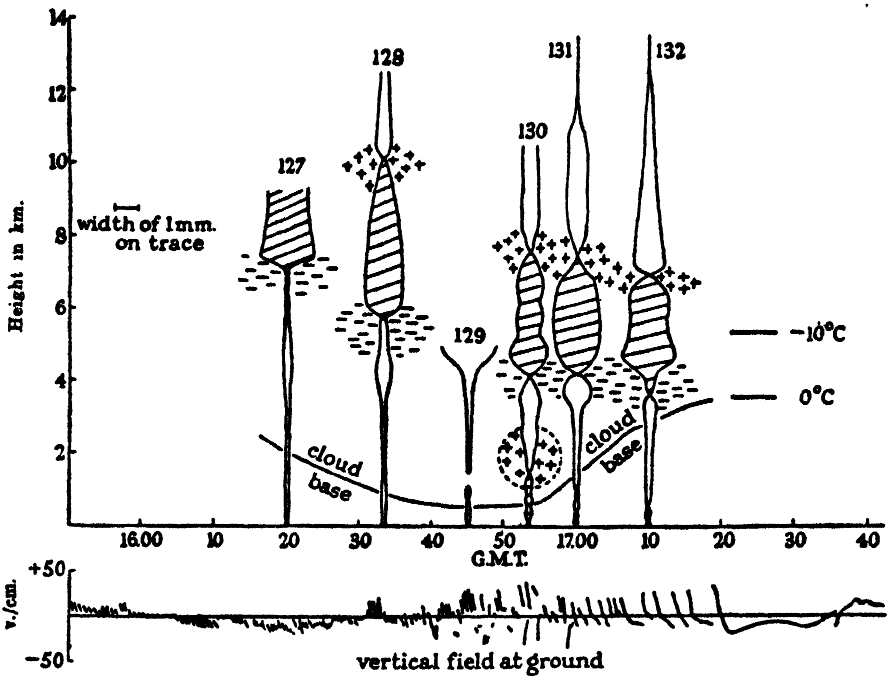


Fig. 6. The electrical field and location of charges in thunderstorm of Aug. 21, 1939 at Kew.
Width of vertical bands proportional to the field ; positive fields hatched, negative fields plain.

I suggested a very simple form of instrument for this purpose, and asked him to go into the matter at Kew. He put the work into the capable hands of Dr. Scrase who developed a cheap, light instrument which could be carried into thunder clouds on a small balloon, and which was called an alti-electrograph. Between July 1933 and August 1939, 132 alti-electrograph ascents were made of which 91 produced useable records. With Scrase and Robinson I analysed these records and the result was perfectly clear : they showed that in every storm we investigated there was a positive charge at the top of the cloud and a negative charge some distance below it.

Figure 6 represents one of the storms analysed, to indicate the kind of evidence we obtained. Six ascents were made in the storm at intervals of

about ten minutes. It will be seen that in each ascent the field was first negative, then it became positive and finally negative again. Now when the field changes sign as the balloon rises we can assume that the balloon has passed through a charged region; if the change is from negative to positive the charge must be negative while if it is from positive to negative the charge must be positive. It will be seen from the diagram that for at least an hour there was positive charge in the upper part of the cloud and negative charge below it, and four of the ascents penetrated both of these charged regions.

I would like to point out here one significant fact revealed by this diagram and all the other records. In the right-hand margin of Figure 5 the position of the isotherms for 0° and −10°C have been shown. Now it can be seen that practically all the charges are in the region above the freezing layer. It is here that the fields are greatest and obviously where the electrical activity is greatest. Thus whatever the cause of the electrical activity may be, it acts in the region of the cloud where the temperature is below freezing point, i.e. where the precipitation is mainly if not entirely in the form of ice.

It is interesting to recall that in the theories put forward by Wilson and myself we took it for granted that rain was the chief agent in the generation of the electricity of thunderstorms; neither of us seemed to realise that as the greater part of most thunder clouds exists where the temperature is below freezing point, ice might be more important than rain. That has now been rectified and practically everyone now seems to accept that the main source of the electricity in thunderstorms is associated with the ice phase, and not the water phase.

Now to return to the main problem : the last difficulty has been removed by the clear evidence that thunderclouds are of positive polarity so that thunderstorms provide positive charges to the conducting Heaviside layer, and negative charge to the conducting earth. Between these two conducting concentric spheres the field in all fine weather areas is positive, and the thunderstorm dynamo provides current which unceasingly passes between them.

Thus the problem which has troubled us for fifty years appears to be solved at last. But please do not overlook that "appears".

COLLECTION OF SCIENTIFIC INSTRUMENTS OF GEORGE III

The Exhibition of the Collection of Scientific Instruments of George III now open to the public at the Science Museum, South Kensington, conveys a remarkably clear impression of the general field of scientific study and experiment during the latter half of the 18th Century. The instruments, models and apparatus on view were constructed by leading instrument makers of the period for the instruction of the young Prince of Wales, later to become George III, and in turn, of his numerous children. The course of instruction and the experiments performed followed closely the teachings of the Dutch philosopher Gravesande, a disciple of Sir Isaac Newton. One of the most important exhibits is a " Philosophical Table ", recognisable as a laboratory bench. Other items worthy of note are the vacuum pumps made by George Adams and two fine microscopes constructed about 1750.

The Exhibition will remain open until the end of September.

SCOTT OF THE ANTARCTIC

By A. J. Drummond

From time immemorial the spirit of adventure and the quest for knowledge in the farthest parts of the earth have appealed to men. In both polar regions Britain led the way. Southwards, Cook, in 1773, was the first to cross the Antarctic Circle and Ross, in 1841, succeeded in breaking through the pack ice into an unknown sea, reaching what was then considered an exceptionally high latitude (78°) and determining with tolerable accuracy the position of the S. Magnetic Pole. Seventy years later in the desolate wastes of the sub-continent of Antarctica, whose fringes in places had thus been laid bare, Scott and his fellow explorers left a magnificent record of achievement and created a tradition which will live forever. The story of Captain Scott's last journey has rightly become one of the great sagas of our country. Just as an older generation owed much to the endeavours of Herbert Ponting, the official cinematographer of the ill-fated expedition, in translating it to the silent screen, a younger one will likewise pay tribute to Sir Michael Balcon of Ealing Studios who has now retold the epic in technicolour.

Scott of the Antarctic went into production under the direction of Charles Friend shortly before the first Christmas following the second world war. The initial stage in the making of this, one of the most ambitious pictures to be attempted by a British company, was the sending of a small film unit to the Antarctic. During the six months of the trip nearly 30,000 miles were covered and a wealth of background material obtained to depict the more distant and panoramic scenes in a manner truly representative of the setting of the original expedition. A hut on Hope Bay (Graham Land) served as the unit's base ; from there a day's filming frequently meant the scaling, with camera equipment, of a 600-foot hill of ice.

The shooting of the near and medium scenes, especially those in which the principal actors had to appear in obviously natural snowy surroundings, presented some difficulty, as it was clear that no single site would be sufficiently representative of the tremendous variety of photography which would be called for if a sense of realism were to be conveyed. Another difficulty was that the places chosen would have to be reasonably easy of access and yet give the impression of being completely remote. After considerable research the Aletsch Glacier which descends into the Rhône valley from the heights of the Jungfrau massif (Switzerland) was selected to represent the Beardmore Glacier, reputed to be more than twice as large as any other known. These high level shots (see Plates I and II) entailed the transporting of equipment from the railway terminus at Jungfraujoch long distances over the icy surfaces of the glacier. Most of the party were unaccustomed to such altitudes and suffered accordingly from working in the rarified air at 11,300 feet ; some risks, too, had to be taken to achieve the desired effect, and a cameraman nearly came to grief in a crevasse into which he fell.

It will be recalled that the route followed by the Main Polar Party of Scott's Second Expedition starts at Cape Evans, the winter quarters (see Figure 1), and

then traverses the frozen McMurdo Sound to the Barrier—the vast level plain of snow and ice, almost at sea level, and believed to be the permanent ice covering of the sea. Passing the main Barrier depôt (One Ton Camp; 145 miles from the

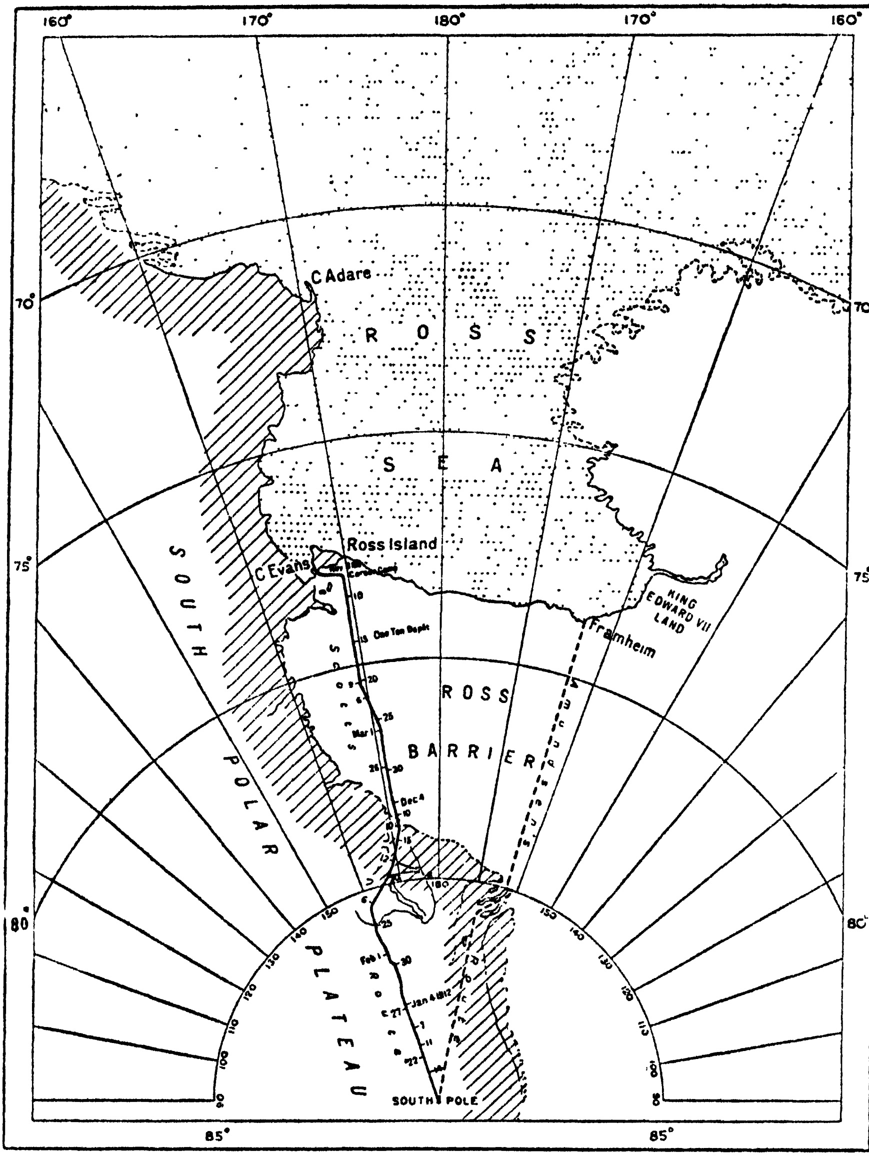
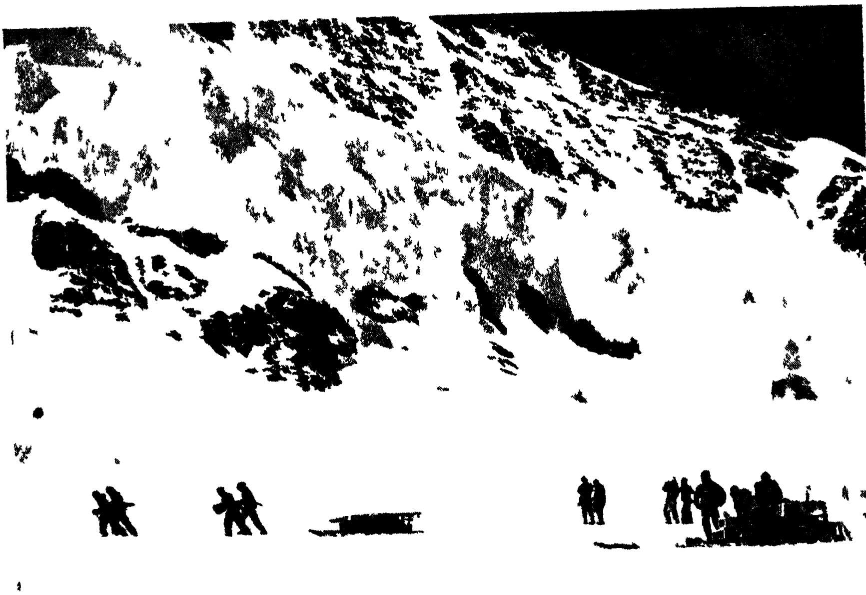


Fig. 1. Sketch-map of the Ross Sea area showing the routes followed by Scott and Amundsen to the S. Pole. (Reproduced by kind permission of the Clarendon Press, Oxford.)

base) the route continues across the Barrier until at a distance of 422 miles from Cape Evans the foot of the Beardmore is reached (Shambles Camp). After 129 miles of difficult and dangerous travelling on the glacier, the range of mountains

Scott's team going strong on the polar plateau (Hardanger Jokul)



One of the teams sets out from the foot of the glacier hauling their sledge with the equipment aboard (Jungfraujoch)

Photographs by] [*Ealing Studios*

PLATE 1

Scott's party find the going hard on the blue ice of the Beardmore Glacier (Aletsch Glacier

The crevasse at the extreme top of the Beardmore Glacier where Lashly fell (Aletsch Glacier)

Photographs by] [*Ealing Studios*

PLATE II

forming the escarpment to a great plateau is finally conquered, and at a further 349 miles from this point (Upper Glacier Depôt) lies the Pole itself. The route rises gently for the first 250 miles or so of this last lap and the crest of the plateau is reached at an elevation of nearly 10,000 feet. From here onwards the height decreases until at the Pole the altitude is just over 9,000 feet.

The Hardanger Jökul above the skiing centre of Finse (Norway) provided the background for the shots illustrating the journeys across the polar plateau. To transport the gear to the 6,000-foot summit horses, man-hauled sledges and Norwegian-Army snow-going caterpillar vehicles had to be employed. The conditions experienced were very trying and even more severe than the first unit had encountered in the Antarctic : the wind blew with hurricane force and it was bitterly cold—so cold indeed that the cameras tended to slow up despite the fitting of special electrical heating devices.

When on location the units had had to adapt themselves to the weather. In the studios the close-ups of outdoor conditions involved the matching of mist, varying densities of snow and cloud effects. A new type of artificial snow was used, its basis being foamed urea formaldehyde ("fuff") which was extraordinarily effective, as those who have seen the film will agree. It was apparently supplied in large blocks and could be used to imitate deep drifting snow, or (with high power fans) to produce blizzards so intense that protective clothing had to be worn on the set.

There can be few who will wish to find fault with the technical accuracy of the presentation. Scott's widow, the late Lady Kennet, made available her extensive Antarctic library and much original matter. First-hand information was obtained from a number of the survivors ; organizations that had been responsible for equipping the expedition prepared replicas, and the Scott Polar Institute at Cambridge lent its co-operation. The amount of detail reproduced is truly astounding ; the extent of the researches may be appreciated from the construction and furnishing of the base hut and the re-creation, in three sizes, of the old whaler " Terra Nova " in which the expedition sailed, the largest nearly full scale and the smallest a perfect model of about three feet in length for certain long shots.

As for the treatment of the subject it is unfortunate, to say the least, that this memorial to a very great gentleman and his comrades ignores so largely the main objective of the expedition, namely the scientific exploration of the Antarctic wilderness. This expedition, when the dual purpose—exploratory and scientific—is taken into account, was probably the best equipped that there has ever been. Far too high a proportion of the film time is devoted to the awful journeys to and from the Pole ; and when all is said and done the Pole was merely the sop to gain financial support from the public. It is true that references are made from time to time to the scientific aspect but, as the number of illustrative shots can be counted on the fingers of one hand, they tend to irritate rather than appease. Moreover, if we are to be deprived of even a sketch of the real background—to say nothing of the various subsidiary sledging journeys—the film has to be seen not as a dramatic race with Amundsen, un-

hampered by scientific commitments, but as a record of great companionship and superhuman endurance. The acting, with John Mills in the title rôle, is sound ; but one rather regrets, the impression of a somewhat hearty, vainglorious and obstinate man, after having believed the testimony of Cherry-Garrard that " Scott's distress on finding he had been beaten by a month was not that of a schoolboy who has lost a race .but that the Polar Journey was literally laid waste." Obviously no trouble has been spared to make what has been selected as authentic and sober a record as possible, and fact has been allowed to predominate over feeling : the deliberate underplaying of such scenes as Scott's first glimpse of Amundsen's flag and Oates's heroic walking out into the blizzard is certainly preferable to the melodrama that so easily could have emerged. The musical score by Vaughan Williams adds greatly to the feeling of the epic. Particularly vivid and powerful are the sections entitled " Blizzard " and " Final Music ".

No praise can be strong enough for the technicolour photography. The shots of the whaler breaking the pack and the penguins jostling to inspect the visitors ; the wonderful greens of the ice : the blue of the sky and the colours of the low sun on the clouds ; and the virgin snows, all contribute to create a sense of desolation, and yet at the same time give rise to a strange fascination. Nevertheless, there can be no excuse to justify the use of a background cloth to depict the environment of Wilson's cottage in such a way that the audience is transported more readily to rural Kent or Sussex than the North of Scotland

No attempt has been made in the foregoing portions of this review to discuss the meteorology of the expedition. This is dealt with fully in Volumes I-III of the official publication, " The British Antarctic Expedition, 1910-1913 ", prepared by Sir G. C. Simpson, K C.B , F R.S., who was meteorologist to the expedition. Those interested are also referred to Sir George's 1923 Halley Lecture, " Scott's Polar Journey and the Weather " (Clarendon Press, Oxford, 1926). It will be sufficient here to remember that Scott's disaster is associated with terrible blizzards on the Barrier and abnormally low temperatures both on the Plateau, where the mean for January 1912 was no higher than −19°F. (i.e. 10°F. lower than Amundsen found during the previous month), and on the Barrier, where on February 28 the night temperature reached the minus forties, remaining there up to the cessation of the temperature record 10 days later. That the air over the Barrier was exceptionally cold after mid-February is borne out by a comparison of the temperatures recorded by the Polar party and at Cape Evans. Before February 15 the temperature at the Barrier was rarely more than 10°F below corresponding values at the base, but with the setting in of the cold winds the temperature at Cape Evans dropped about 10°F. below the average and on the Barrier yet another 30-40°F. lower. The lowest temperature which has been reported on the Barrier (and anywhere in the Antarctic) was −76°F. during the previous winter, on July 6, 1911 ; at Cape Evans the simultaneous temperature was −43°F.

The accompanying table which summarizes the temperature and wind observations made at Cape Evans during the several expeditions over the

period 1902-1912 may be of interest to some readers. The data have been extracted from Volumes I and III of the official account.

Table 1. Mean values of temperature and wind in the vicinity of Cape Evans (McMurdo Sound)

	Temperature (°F.)					Wind (mi./hr.)		Wind Frequency (%)		
	Hourly Mean	Mean Max.	Mean Min.	Abs. Max.	Abs. Min.	Hourly Mean	Max. in 1 hour	Over 40 mi./hr.	Calms	SSW. to ENE.
No. of Years	5	4	4	4	4	4	1¾	1¾	1¾	1¾
Jan.	23·7	28·9	16·9	39·9	4·0	9·1	54	2	10	81
Feb.	15·8	20·0	8·7	33·1	-9.5	16·3	63	16	5	91
Mar.	4·4	9·4	−2·2	27·5	−20·0	17·9	68	20	1	85
April	8·8	-2·0	15·5	19·5	-42·0	14·3	60	9	3	72
May	-10·5	-5·2	-20·7	17·0	-51·2	16·0	81	17	16	60
June	-11·9	4·9	−22·4	20·6	−47·0	17·0	73	24	12	77
July	-14·6	-6·1	23·6	15·9	−54·2	17·1	79	27	15	78
Aug.	−14·6	−6·5	−23·8	17·8	−53·2	16·8	66	21	12	76
Sept.	−11·7	−5·1	−22·7	15·9	−58·5	14·5	57	15	15	64
Oct.	−2·1	2·2	-12·1	24·1	-42·8	14·3	59	10	9	72
Nov.	14·2	18·6	7·3	34·0	-6·5	13·5	43	2	10	80
Dec.	24·9	28·6	18·3	42·0	4·2	10·4	48	3	17	59
Year	0·7	6·5	-7·7	42·0	-58·5	14·8	81	14	10	75

Notes: The dates of the observations used in the table were: for column 1, 1902, 1903, 1908-09, 1911, 1912; for columns 2-6, 1902, 1903, 1911, 1912; for columns 7-10, 1911, 1912.

In column 9, a calm is an hour with wind run up of 0·1 mile. In column 10, the importance of these winds is that they had traversed the Ross Barrier—they were known as "Barrier Winds".

SCIENCE NEWS*

Edited by J. L. Crammer — Penguin Books Ltd.
160 pages, 31 plates — London, 1949, 1s. 6d.

Meteorologists who regularly read Science News will receive an extra thrill when they open the latest issue, No.11, for three of the ten articles are of direct concern to them. The article by James Paton on the Aurora Borealis is a welcome enlargement of his earlier contributions to *Weather* (May 1946, pp. 6-11 and March 1947, pp. 80-81) *The Moon and the Weather*, by K. G. Collier, is a simple exercise in scientific method—it is very doubtful if his conclusions will convince the numerous people who believe that the weather changes with the moon Professor O. G. Sutton's article, *The Restless Wind*, is a popular account of turbulence, with no mathematics apart from two very simple equations and a third which is given as a footnote—presumably because it contains a differential coefficient. It is a great gift to be able to express oneself equally clearly in mathematical and non-mathematical language and Professor Sutton is to be congratulated on his achievement Elsewhere in the book, readers with more catholic tastes will enjoy reading about *Life in Graham Land*, *The Structure of Proteins* and *Occupational Health*: no mention is made of any occupational diseases of meteorologists.

O.M.A.

PILOT-BALLOON THEODOLITE DEVELOPMENT

By J. A. Armstrong

The speed and direction of the winds in the upper atmosphere have for many years been measured by tracking a balloon with a theodolite. Thepilot balloon, after being inflated with hydrogen until it can support a known weight, is released and ascends at a rate that is nearly constant. At the same time it is carried along horizontally by the wind and changes its position according to the direction and strength of the wind at the various levels. Readings of the balloon's elevation and azimuth are made with the theodolite at regular intervals, usually every minute For the most accurate work, two theodolites are used separated by a known distance. The plan position of the balloon at the times of observation can then be calculated and the velocity of the wind deduced.

The principle of measuring in elevation and azimuth is one which the surveyor and astromoner had to solve many hundreds of years ago, and the balloon theodolite was evolved from the surveying theodolite. This consists primarily of a telescope mounted on a horizontal axis, the cradle for which rotates about a vertical axis. Graduated circles are fitted to both axes of rotation so that the angular position of the telescope can be defined. Provision is made for levelling the instrument by precision spirit levels and for accurately adjusting the position of the telescope.

The surveyors' theodolite, however, when applied to locating a pilot balloon is by no means ideal. Elevations up to 90° are encountered and speed of operation is a vitally important consideration—the surveyor, although he has no wish to waste time, is not concerned to the same extent. The original pilot balloon theodolite was designed by de Quervain in 1905 ; the chief feature by which it differed from the normal surveying theodolite was that the telescope tube formed the horizontal axis of rotation and the objective was mounted in front of a right angle prism The observer could thus look horizontally and rotate the telescope to view at any elevation.

An early instrument on these lines, the Cary Porter Mark D is shown in Fig. 1. The circles are read by means of verniers and it was not easy to take the readings quickly. The Watts Mark B (Fig. 2) which appeared about 1921 represented a step forward in design in that it was a much quicker instrument to use. The elevation and azimuth movements were still obtained by worm wheels but these were provided with drums graduated with divisions equalling 1/10 of a degree. Readings were obtained by observing to the nearest degree on the horizontal and vertical circles through the two windows, and adding the readings shown on the drums against the index lines.

Various modifications were made to the Mark B in subsequent years, the chief addition being electric illumination of the scales and telescope diaphragm, but no major redesign was brought out until 1938. As a result of an investigation into the faults of the instruments then in service, R. Cranna of the Meteorological Office assisted the manufacturers to design a totally new instrument of greatly improved performance . the M.O Pilot Balloon Theodolite Mark I (Fig. 3.) was the result.

One of the disadvantages of earlier instruments had been that the field of view of the telescope was only 1.5 to 2 degrees, which made it very difficult to find the balloon in the first place and to remain trained on it. In the Mark I the magnification adopted was 24 diameters with a field of 2°, but an additional secondary wide angle telescope was incorporated having a magnification of 6 diameters and covering a field of 8 degrees. By turning a small lever it was possible to swing out a small mirror in the system so that the observer could

change from one field of view to the other without moving the eye. The low magnification telescope was sufficient to follow the balloon for a distance of a mile and was found of great assistance in finding a balloon at night. Because of the increase in the number of nightly ascents, night illumination of all the scales became an integral part of the instrument.

It was apparent from observers' comments that further concentratiòn of scales and hand wheels was necessary. By an ingenious method of bevel gearing the elevation circle was made to run parallel to and immediately above the azimuth circle. Thus both circles were visible through one window directly under the eyepiece and were read against a single index line. The operation of the instrument was still by worm screws reading to tenths of a degree; these were made to disengage independently, but so arranged that the hand wheels and clutch levers for both could be operated by one hand. To illuminate the

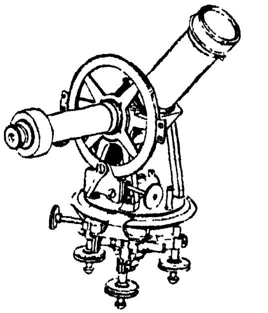


Fig. 1. Cary Porter Mark D.

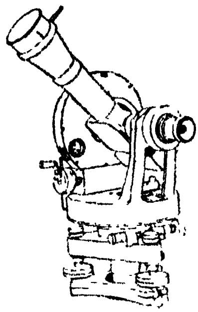


Fig. 2. Watts Mark B Pilot Balloon Theodolite.

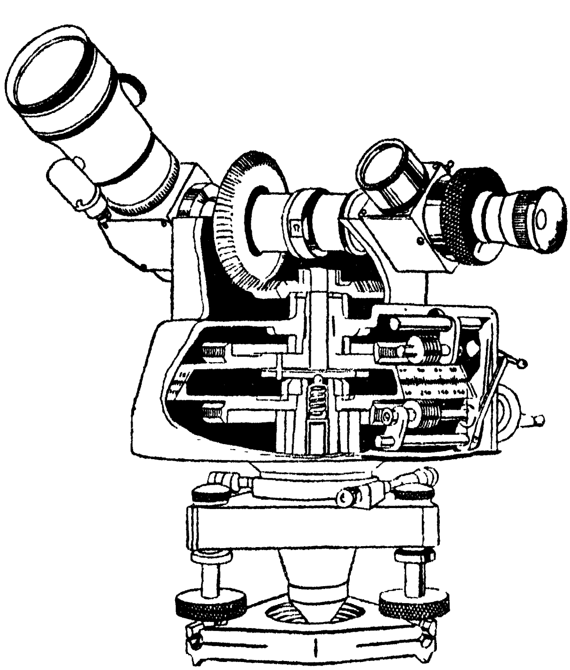


Fig. 3. Watts Pilot Balloon Theodolite Mark 1.

scales at night a lamp bulb was situated above the window, which also served to illuminate a stop-watch, and a second bulb on the telescope illuminated the cross-lines in the eyepiece.

Further modifications were made during the war to improve the weather proofing and resistance to corrosion, the accuracy and the sighting ability of the main telescope, and the Mark IV instrument at present in use represents the latest advance in design.

It remains to be seen what will be the ultimate effect of the development of radar upon the use of an optical sighting instrument. Stations equipped with radar can readily track a balloon fitted with a reflector and obtain directly the instantaneous slant range, elevation and azimuth of the balloon, at day or night. Nevertheless, radar is not always available, and in such circumstances the optical instrument will still hold its own.

This article will be concluded next month.

ROYAL METEOROLOGICAL SOCIETY NEWS

SOME INTERNATIONAL ASPECTS OF METEOROLOGY

When Sir Nelson Johnson gave the fourth of a series of popular lectures in the Lecture Theatre of the Science Museum, on Thursday, February 10, Mr. E. Gold introduced him, not as Director of the Meteorological Office, but as President of the International Meteorological Organization.

The history of the I.M.O. began in 1853, said Sir Nelson, when an international group of seamen held a meeting in Brussels to organize meteorological observations over the oceans. One consequence was the formation of the London Meteorological Office, as part of the Board of Trade. Its first director was Vice-Admiral Fitzroy, who had earlier been associated with H.M.S. " Beagle " and Charles Darwin, and with Rear-Admiral Beaufort, the Hydrographer of the Navy. Fitzroy introduced gale warnings for coastal waters, the messages being transmitted to the ports by the newly invented electric telegraph

Congresses in Vienna, 1873, and Utrecht, 1878, led to the formal foundation of the International Meteorological Organization, with facilities for general meetings, permanent committees, and technical commissions for specific branches of the work. Its first president was Dr. Buys Ballot : Sir Napier Shaw was president from 1907-23.

Up to 1918 the I.M.O. existed chiefly for the benefit of seamen, though its technical commissions dealt with such matters as terrestrial magnetism and electricity, radiation, and the exploration of the upper atmosphere. After 1918 the demands of aviation for weather forecasts led to vast developments. The Commission for Synoptic Weather Information was formed, with Mr. E. Gold as president from 1919-47. This was by far the most important, the most active and, if Sir Nelson might be permitted, the most controversial of the I.M.O. commissions.

Sir Nelson referred to the present form of the I.M.O., and to the new and more official status it was now in the process of acquiring. He mentioned the new weather code (see *Weather* Oct. and Dec. 1948, pp.300 and 354), the great *International Cloud Atlas*, the *Réseau Mondial*, and the scheme of International Meteorological Days for the mass exploration of the upper atmosphere in the epoch before the introduction of the radio-sonde.

The I.M.O. was by no means the only international body connected with meteorology. There was the International Union of Geodesy and Geophysics (see *Weather*, Oct. 1948, p. 305), whose delegates were mainly the I.M.O. delegates with their hats turned the other way. The International Civil Aviation Organization had produced the recent development of Ocean Weather Ships and, earlier, the I.C.A.N. Atmosphere. Important contributions to meteorology were also made by the International Organization for the Standardization of Instruments, the International Telecommunications Union, and the International Federation for Documentation.

A.R.M.

WAVES AND SWELL

The Symons Memorial Lecture was given at the Society's rooms on April 20 by G. E. R. Deacon, F.R.S., under the title "Waves and Swell". Following the lines of his recent article in *Weather* (March 1949, p.74), the lecturer described how the war-time needs for accurate information about waves—he instanced the value of the forecasts made for the Normandy beach landings—had led to a great advance in knowledge about the origin and propagation of ocean waves. As the rate of damping of waves was so small, only amounting to 50% after a travel of 2000 miles in the case of a wave of 2000 ft length, it was possible to detect waves which had been generated by storms thousands of miles distant. It had been found that the longest waves travelled at the speed of the gradient wind in the area where the waves were being produced. This was a useful relationship, but to obtain more detailed information about the connection between wind and waves it was necessary to measure the wind much closer to the sea surface than the height at which it would approximate to the gradient wind. Measurements were being made on Lough Neagh of wind profiles close to the surface — Dr. Deacon thought that even as he was speaking Professor P. A. Sheppard would be taking readings from sensitive anemometers in the middle of Lough Neagh, 3000 yds. from the land !

Dr. Deacon showed how sea waves had similar properties to other waves which had been the subject of much more detailed scientific study. They could be refracted when approaching estuaries and diffracted by such obstacles as breakwaters. Our knowledge was still far from complete : for example the magnitude of backward undercurrents for beaches was still unknown, although they could be investigated by such a simple procedure as attaching a football bladder filled with salt water of appropriate density at the end of a fishing line !

The Chairman, Sir Robert Watson-Watt, reminded the audience that the tradition of the Symons Lecture was that it should not be followed by discussion, but with the lecturer's consent he proposed to break this tradition. Among the contributors to the discussion were Mr. E. Gold, who recalled how he had passed the time during a recent voyage by estimating the distance of the origin of the regular rollers in the South Atlantic by the changes observed on successive days, and Mr. T. H. Kirk, who wondered if the new reports from merchant ships of period and height of waves would be of more value than earlier reports in which attempts had been made to differentiate between waves and swell.

POPULAR LECTURE

On Wednesday, April 6, at 6 p.m., in the Science Museum Lecture Theatre, Dr. G. M. B. Dobson gave an interesting lecture on "Some solar and terrestrial relationships." Dr. Dobson has kindly consented to write a short version of this lecture for *Weather* in the near future.

MIDLAND CENTRE

The second annual Summer Outing will be held on Saturday, May 21. Arrangements have been made for a party to visit Kew Observatory by coach. Fellows and friends wishing to participate are advised to book early as only a limited number of seats are available. Further details may be obtained from Mr. H. E. Howle, F.R.A.S., Norton House, 23 Nicholls Street, West Bromwich.

ACKNOWLEDGMENT

The Council acknowledges with sincere thanks a gift of milk from Dr. M. A. Barnett of Wellington, New Zealand, and of tea from Lieut. Cdr. P. G. Satow, D.S.C., R.N., for use when tea is served prior to the monthly meetings of the Society. Owing to the generosity of these and other Fellows, there is now no risk of shortage during the next 12 months.

FORTHCOMING MEETINGS

On Wednesday, May 18, at 5.0 p.m., in the Society's rooms, a discussion on "The General Circulation of the Atmosphere" will be opened by E. T. Eady, B.A., Ph.D., A recent paper by C. H. B. Priestley, M.A., F. Inst. P., "Heat Transport and Zonal Stress between Latitudes" will be read, and a contribution to the discussion will be made by R. C. Sutcliffe, O.B.E., Ph.D.

On Thursday, June 9, at 5.30 p.m., in the Department of Natural Philosophy, Edinburgh University, Sir Nelson K. Johnson, Director of the Meteorological Office, will address a meeting of the Scottish Centre on "The Organisation and Work of the Meteorological Office."

THE ELEMENTS RAGE*

188 pages
46 plates

By Frank W. Lane
Country Life Ltd.
London, 1948, 1s. 6d.

All of us have at one time or another asked such questions as :—"How big were the largest hailstones ever recorded ?". "How much rain can fall in one day ?". "How much energy is dissipated in a thunderstorm ?". The answers to these and many other similar questions will be found in the second edition of *The Elements Rage*. The author has assembled an amazing collection of facts, dealing with all the most violent manifestations of Nature and has strung them together with a straightforward narrative to make a very readable book, which will appeal to young and old alike. No less amazing are the photographs with which the book is illustrated ; even a hurried glance through the plates would be a vivid reminder of the many natural hazards that we humans have to face.

Although Mr. Lane has tended to stress the sensational aspects of his subject, he has not done so at the expense of accuracy ; he has obviously taken great pains to verify every statement— would that some of our more emotional Sunday newspapers would follow his example ! He has consulted many well-known experts, including Dr. C. E. P. Brooks, I. R. Tannehill and S. Morris Bower and, where he differs from them in a matter of opinion, both points of view are given.

The titles of the Chapters, Hurricanes, Tornadoes, Waterspouts, Hail, Snow, Lightning, Meteorites, Earthquakes and Volcanoes, show the wide range covered. It is at first surprising that no mention is made of extremes of temperature, atmospheric pressure, humidity and some of the other common meteorological elements ; no doubt more information about these subjects will be given in a future edition when somebody has taken a photograph which immediately suggests the feeling of 140° F. in the shade ! Bare statistics would be of little use in this text, but a few outstanding figures might have been awarded a place in an appendix.

O.M.A.

*Review

THE WEATHER OF APRIL 1949

VERY WARM; EXCEPTIONALLY SUNNY IN SOUTH AND EAST.

The weather during April was notable for the many sunny days enjoyed in the South, East and Midlands, for unusually high average temperatures generally (between 5° F. and 6° F. above normal) and for the sunniest and warmest Easter for about 50 years. Rainfall was again below normal in many areas though in the North-West figures were high.

At the beginning of the month a south-easterly type was gradually being replaced by a south-westerly one which became established by 3rd. On the evening of the 3rd a depression moving north-eastwards off Western Scotland was associated with south-westerly gales for a considerable distance to the south and east of its path. Gusts of 70 m.p.h. were reported in the Straits of Dover and the liner "Queen Mary" was 24 hours late in docking at Southampton In the Fenlands around Ely dust clouds 100 feet high were blown by the gale from fields that were exceptionally dry, while flooding occurred in the West and North. On 7th a north-westerly current of air behind a depression moving eastward over Denmark caused temperatures to fall generally; snow was widespread in the North and was 2 inches deep in some of the Lancashire and Derbyshire hills. On the night of 8th to 9th screen minima of 29° F. to 32° F. were fairly general and damage was done to early potato crops in Cornwall.

On 14th a warm front heralded a change to a south to south-east type. Cloudless skies, warm and dry air from South-West Europe and a low inversion (under 3,000 ft.), contributed to give temperatures exceeding 75°F over much of England during the afternoon of 16th. During the four days from Good Friday to Easter Monday there were over 40 hours of sunshine over much of England, and while the temperature on 16th stood at 85°-85° F. in many parts of Southern England (85° F. at Camden Square), there was ski-ing on the Cairngorms. From 19th to 28th a westerly type prevailed and some very welcome rain fell. On 29th pressure rose to west of Ireland and the last two days were rather cold because of the northerly air stream.

Weather news from abroad has been scarce. We hear, however, of violent storms and serious floods in Morocco, while in France and Italy the shortage of rain is adversely affecting not only crops but also electric power supply. Drought is also being experienced in Tanganyika where cotton, rice and groundnut crops will be small.

	TEMPERATURE (°F.)				RAIN (mm.)*			SUNSHINE (hr.)		
	Long period Average Max.	Long period Average Min.	This month Extreme Max.	This month Extreme Min.	Month	Diff. from Av.	Last 12 months	Month	Diff. from Av.	Last 12 months
Kew Obsy.	54·6	40·8	79	32	38	— 7	486	211	+65	1448
Gorleston	50·7	40·6	73	34	37	1	501	200	+36	1657
Birmingham	52·2	39·4	75	33	61	+17	772	162	+35	1355
Falmouth	53·3	42·5	†60	†37	42	—25	829	184	— 3	1701
Valentia	52·4	42·4	60	35	97	+ 9	1310	111	—50	1205
Aldergrove	52·3	38·3	63	28	49	— 9	848	123	—30	1267
Holyhead	50·1	42·4	63	31	47	— 6	752	154	—20	1507
Tynemouth	49·3	39·7	67	34	53	+17	549			
Renfrew	51·9	37·0	66	32	109	+52	1257	143	+10	1251
Aberdeen	48·7	36·3	66	29	24	—31	811	164	+ 6	1456
Stornoway	48·8	38·1	56	31	106	+22	1277	113	—37	1213

* 25 mm. = 1 inch (approx.) † The Lizard

C.R.B.

WEATHER OVERSEAS

In the two years since the appointment of our Overseas Representatives, we have published articles and news items from many parts of the world, which have been of great interest to readers at home and abroad. Several changes have been made in the list published in our issue of March 1947, and an up-to-date version is therefore given below ; we hope to be able to announce several additions to the list in the near future. We would like to take this opportunity of thanking our Representatives for their assistance in increasing the international aspects of *Weather*.

AUSTRALIA : H. N. Warren, P.O. Box 1289 K., Melbourne, C.1.
BERMUDA : W. A. Macky, Meteorological Office, Hamilton.
CANADA : A. Thomson, Meteorological Office, Bloor Street, Toronto, Ontario.
EGYPT : M. H. Gidamy, Meteorological Department, Ministry of War and Marine, Cairo.
HONG KONG : L. Starbuck, Royal Observatory, Hong Kong.
INDIA : S. K. Banerji, D.O. No.0230, Indian Meteorological Department, New Delhi.
RHODESIA . J. S. Peake, Meteorological Office, P.O. Box 378, Salisbury.
S. AFRICA : T. E. W. Schumann, 73 Anderson Street, Pretoria.
SUDAN . A. W. Ireland, G.P.O., Khartoum.
U.S.A. : R. N Culnan, U.S. Weather Bureau, Washington 25, D.C.

HEAVY RAINFALL IN AUSTRALIA

The article " Eight Yards of Rain " by Mr. F. Lord (*Weather* September 1948, p. 279) has led to some correspondence about his statement that at Deeral, in North Queensland, 13 inches of rain had been recorded in one hour. According to the local observer, Mr. R. G. Robinson, the records only go back to 1929 since when the "highest single measurement recorded here, was on March 1st, 1935, when 21.38 in. of rain fell between 9 a.m. and 4 p.m." The heaviest rainfalls recorded in 24 hours in Queensland are :

35.71	inches at	Crohamhurst on 2nd February 1893.
34.72	,, ,,	Traubanaman on 8th February 1918.
30.65	,, ,,	Yarrabah on 2nd April 1911.
28.80	,, ,,	Kuranda on 2nd April 1911.
27.80	,, ,,	Springbrook on 24th January 1947.
27.75	,, ,,	Harveys Creek on 3rd January 1911.
27.60	,, ,,	Deeral on 2nd March 1935.
24.14	,, ,,	Babinda on 2nd March 1935.
23.86	,, ,,	Tully on 12th February 1927.

THUNDERSTORM CONTROL IN U.S.A.

In the North West of the United States 75% of the forest fires are attributed to lightning strikes. It is primarily this fact which has prompted V. J. Schaefer (*"Cirrus" Report* No. 11) to urge a series of experiments in this region to test the practicability of reducing or inhibiting thunderstorm activity by seeding growing cumulus clouds with solid carbon dioxide (dry ice).

Schaefer argues that the supercooled water droplets in a growing cumulus cloud are a source of energy which is released when the cloud particles begin to turn to ice (latent heat of fusion) ; in a potential thunder cloud a large measure of supercooling occurs, the cloud particles being water 10,000 ft. and more above the freezing level. If, however, the supercooled water droplets can be persuaded to freeze at an early stage by the introduction of dry ice or other artificial

means, then the release of energy may not be so sudden as would occur naturally and thunder may be avoided.

If Schaefer's ideas are proved correct—and he emphasizes the need for thorough experimental verification—they may have useful applications in other parts of the world where thunderstorms often cause serious damage either by lightning or by hail.

MICROMETEOROLOGY IN AMERICA

After a tour of U.S.A., during which he delivered a course of lectures to the staff of the Weather Bureau, Professor O. G. Sutton gave an account of his scientific experiences to Meteorological Office staff and guests on Thursday, February 24. He had been impressed by the alertness of his American audience, and almost embarrassed by its size at the 16 lectures . but as his London talk progressed it became obvious that here, too, a whole course of lectures would have been received with enthusiasm.

In micrometeorology, Professor Sutton considered, Great Britain had been ahead of any country in the world in 1939, but recently the importance of the subject had notably increased, and in response several great research programmes had begun in the U.S.A. The increase was largely due to the rising risk of atmospheric pollution from industrial plants. He foresaw also that a micrometeorological approach would be made to research on soil conservation : rather than add to existing data about average conditions—*i.e.* climate—it would be profitable to make surveys of local conditions, possibly with mobile meteorological units and to measure directly the gradient of wind, temperature and humidity. Further, it had been shown at the Ministry of Supply Research Department at Porton that, with careful control of such factors as grass surfaces upwind, micrometeorology can approach the accuracy of the laboratory.

EDDY DIFFUSION

Two outstanding features of the American research projects were their magnitude and the excellence of the instrumentation. Though no instrumentalist, Professor Sutton was prepared to assert that the beautiful recording apparatus he had seen was all that could be desired by weather men.

At Brookhaven, Long Island, a group of universities had combined to study the diffusion of material emitted from chimneys. The experimental smoke was produced by army-type generators, and emitted from one of two 420 ft. towers of open steelwork, or from any point beneath a cable slung between them. There were instruments for recording the start and end of precipitation, smoke densitometers, a special kind of recording galvanometer, and even a device for carrying records past the eye of a computer. There were vehicles completely fitted out as mobile laboratories, and the station possessed its own aircraft for measuring temperatures, all with radio inter-communication and means of securing simultaneity of observations. An interesting scheme was afoot to study inversions above the level of the towers by the anomalous transmission of sound.

At Camp Detreck, an attempt was being made to obtain a detailed picture

of the fine structure of the lower atmosphere over a limited area by setting up a number of short masts, each with a complete temperature recording unit of high sensitivity. The records he had seen were extremely interesting. He was also interested in the thermocouples used, of very small size, which, according to a pronouncement from John Hopkins University, required no aspirators or screening from solar radiation.

Referring to the balloon-scattering project of the U.S. Weather Bureau, Professor Sutton recalled the early work of L. F. Richardson and D. Proctor on very large scale diffusion (see *Weather*, January 1949, p.8), based on such information as could be got from the Krakatoa dust and toy balloon races. At first the eddy diffusivity K had been treated as a constant, but the investigations shewed K to vary over the range 10^3 - 10^8 cm.^{2}/sec., which was "rather tough, even for meteorology". He had proposed a semi-empirical law for the dependence of scattering (σ) on distance travelled (d), viz. σ^2=const. $\times d^{1.75}$, and this appeared to hold for a wide range of d. The Weather Bureau had set out to verify or improve this relation. One method was to release a tied group of balloons, arranged to rise to a predetermined height before the strings were automatically broken. Each balloon, fitted with a constant-height device, was then followed by radar. Not more than ten balloons could be separately tracked in this way at a height of the order of 20,000 ft., and tests were at present being made with groups of five. Professor Sutton invited suggestions for improving the statistical design of the experiments, but felt that this problem was exceptionally difficult.

ATMOSPHERIC POLLUTION

The Americans had become very conscious of the problem of urban smoke and fog, which they contracted to the expressive portmanteau word "smog". At Donora, Pennsylvania, there had been 17 deaths in one day during recent foggy weather, and special investigations were being made by the Industrial Hygiene Foundation which was part of the famous Mellon Institute of Pittsburg. Professor Sutton had been asked to form an estimate of the concentration of pollution in the Donora valley under adverse weather conditions, but in the absence of micrometeorological data had been reluctant to do so. He was deeply moved by the complete absence of vegetation on undisturbed ground in the bottom of the valley, although there was plenty of green growth higher up the slopes.

A general investigation of atmospheric pollution was being made in other American cities. In Los Angeles a useful practical method of forecasting smog had been developed by the Air Pollution Control. They plotted the height of the 700-millibar level above or below the normal value, as the three-day accumulated height difference, against the accumulated wind movement in the same period. They found that smog occurred if, and only if, the wind movement was small and the 700-millibar level was high.

The new power station of the Edison Company near La Guardia Airport presented a different kind of problem. Almost the only way to prevent an undue concentration of pollution near ground level was to emit the flue gases

at the top of high stacks, but near an airport high stacks are not permissible. Professor Sutton had been asked to calculate the probable concentration from low stacks but he confessed that his own method (*Quart. J.R. Met. Soc.*, 1947, Vol. 73, p. 257; *Weather*, August 1947, p. 249), was not applicable to a built-up area like New York. In fact he gave a warning, particularly to non-meteorologists, against the danger of mis-applying the method. His only suggestions on the La Guardia problem were tests using models in wind tunnels, and surveys to find the high spots of atmospheric pollution already in the neighbourhood.

In conclusion Professor Sutton endorsed Sir Nelson Johnson's reference to American kindness and hospitality in his introductory remarks. He had had a wonderful two months in U.S.A. Even more, he had been impressed by the significance of the work being undertaken and the enthusiasm and energy with which it was being pursued. Micrometeorology was now coming into its own.

A.R.M.

SOUTH AFRICAN RAIN-MAKING EXPERIMENTS

The South African Council for Scientific and Industrial Research, with the Division of Meteorology and the South African Air Force, made experiments on cloud seeding during the summer of 1947-48*. Dry ice (solid carbon dioxide) was dropped into the tops of 36 cumulus clouds at temperatures below freezing during a series of seven flights and the results were observed by means of a 3 cm. wave length radar on the ground as well as visually from aircraft.

On 20 occasions radar echoes developed and on 8 more the echoes observed were doubtful because of permanent echoes. In 4 cases echoes did not develop until 90 minutes or more after the seeding and in the remaining 4 there were no echoes at all. As is usual with such experiments it was difficult or impossible to determine whether the development which was observed after seeding was the result of the seeding or would have occurred naturally in any case. However the results of one of the flights seem to indicate that the showers and the radar echoes observed after seeding could not have occurred otherwise.

Water was sprinkled on the clouds on several occasions on one of which the clouds later gave radar echoes though whether this was due to the seeding water or whether rain was formed was not known. Apart from the cloud modification achieved, the interesting point was established that radar echoes were sometimes received from clouds which were not precipitating. With radar of wavelength 10 cm. or more it is generally assumed that only precipitating clouds will give a response.

This South African report confirms earlier experiments (see, for example, the article 'Rain Making' in *Weather*, Sept. 1948) that on suitable occasions rain may be induced by seeding clouds with dry ice. It does not indicate, however, how often such cloud seeding might be successful in producing rain and recent American trials (*Bull. Amer. Met. Soc.*, Vol. 29, May and Dec., 1948), would indicate that only rarely is it possible to cause rain which would not otherwise have fallen.

****South African C.S.I.R. Report, Series M***, "Artificial Stimulation of Precipitation 1948."

J.K.B.

UNUSUAL DAMAGE BY A TORNADO

By E. S. Davy
Assistant Director, Royal Alfred Observatory, Mauritius

The island of Mauritius in the South Indian Ocean is in a region in which tropical depressions or " cyclones " frequently develop and move; small tornadoes or whirlwinds are, however, rarely reported here.

On May 24, 1948, at Curepipe, Mauritius (approximately 1,850 feet above sea level), a phenomenon of the tornado type exhibited a very interesting feature which the writer has not seen mentioned in reports of other tornadoes. During most of the day the weather was mainly fair at Curepipe and convection appeared to be no more intensive than is normal for this region. In the middle of the afternoon a whirlwind touched down to earth over a hard tennis court, causing considerable damage to its hard compact surface. A trench running in a north-south direction, 60 feet long and 1 to 2½ feet wide, was cut in the bare surface of the court to a depth varying from 1 to 4 inches. The material lifted from the trench was all thrown to the west to a distance of 50 feet; pieces weighing about one pound were thrown as far as 30 feet. The surface material was slightly blackened as if by heating, and a crackling like that of a sugar-cane fire was heard for two or three minutes. The court was made of a ferruginous clay, which packs down to a surface more smooth than that of the hard tennis courts usually made in Great Britain.

Unfortunately, there were no very reliable witnesses of the phenomenon. The impressions gained by two servants of the tennis club who saw the incident differed considerably on important details. One claims to have seen a ball of fire about two feet in diameter which crossed from a football pitch to the tennis court through a wire-netting fence without leaving any evidence of its passage until it bounced along the court, making the trench in the surface before disappearing completely.

The high winds and ascending currents in this small tornado were unusually irregular in their action; on the tennis court an umpire's chair weighing about 50 pounds was picked up from 50 yards to the west of the trench, carried upwards to an estimated height of 60 feet, said to have been broken whilst in the air, and dropped in pieces about 20 feet to the east side of the trench, that is, on the side opposite to the pieces of court surface. A hundred yards to the south of the tennis court the roof of a small building was lifted off and dropped nearby. About two miles to the north a rather insecure building was blown over as the whirlwind moved in a northerly direction. No other evidence of damage to buildings or vegetation was reported nor could any be seen from a hill-top which was in the track of the phenomenon, between the damaged sites of which a good view was obtained.

At the Aerological Station, Vacoas (1,393 feet above sea-level), 1½ miles to the west of the destroyed building, there was no wind at 1 p.m.; between 2 and 3 p.m. the wind rose gradually to an average of 7 m.p.h. (highest gust 15 m.p.h.) and fell again to very light; during the same period the wind

direction changed from west-south-west through south to east-south-east. There was no wind after 4 p.m. The Aerological Station was therefore under the influence of the whirlwind and the circulation was clockwise, as one would expect in a low-pressure system in the southern hemisphere. At the tennis court there was no rain at the time the whirlwind passed, but heavy rain started five minutes later and continued for twenty minutes. At the Aerological Station no rain fell: there was no thunder reported.

An explanation of the mechanism by which the bare surface of the tennis court could be lifted out is difficult to find. It seems most probable that it was an electrical discharge which disrupted the court surface; this would also account for the light, the blackening of the surface and the crackling noise. It seems improbable that high winds and a sudden atmospheric pressure change could have much effect on a closely packed earthy material with a smooth surface.

DEVELOPMENTS IN THE ANTARCTIC

By G. A Howkins

In 1943, His Majesty's Government made arrangements to resume scientific and survey work in the Falkland Islands Dependencies. During the first season a party under the leadership of Lt.-Cdr. J. W. S Marr, R.N.V.R.—who made his first visit to the Antarctic with Shackleton—established bases at Deception Island and Port Lockroy. Each successive season has seen the opening of more bases until, in 1948, there were parties at Signy Island, Hope Bay, Admiralty Bay, Deception Island, Port Lockroy, Argentine Island and Marguerite Bay.

Work has embraced all the usual activities of Antarctic expeditions, including marine biology, geology and glaciology, though in the later stages, greatest importance has been attached to survey and meteorology. Survey parties have covered hundreds of miles by sledge from Hope Bay down the east and north coasts of Graham Land and both north and south from Marguerite Bay. It is now proposed to complete the work of the sledge surveys by aerial photography from Marguerite Bay and by a coastal survey, using a 45-ton ketch, from Deception Island.

Meteorological observing at first tended to follow the lines of previous Antarctic expeditions, though with the disadvantage that, in the early stages, the survey was hurriedly conceived and it was difficult to obtain suitable staff and equipment. Early work has therefore tended to be sketchy and uncoordinated, but recent decisions taken by the Governor of the Falkland Islands Dependencies, to whom the control of the administration of the survey has been transferred, have prepared the way for a meteorological organization which is without precedent in the Antarctic. Steps are being taken under the auspices of the British Meteorological Office to build a small meteorological service based on Stanley, in the Falklands, and including a number of semi-permanent stations situated at points in Graham Land and on certain of the islands in the Antarctic Dependencies.

The primary aim of the service will be to collect synoptic data from these stations for a routine synoptic analysis of the area. This, it is hoped, will go far towards providing the data which are still required to settle some of the unsolved theoretical problems of the area ; the combination with this work of extensive geographical and glaciological survey will add greatly to the chances of its success.

It is also intended that the widest practical use should be made of the information. To this end synoptic reports are already being broadcast 3 times daily from the Falklands in collective messages (FICOL), which are used by South American countries and South Africa. The reports are also used in Stanley, where they assist materially in local forecasting, and the Naval Meteorological section in Simonstown, South Africa, is developing a system of long-range forecasting employing this data. FICOL were also used by the British meteorologist H. H. Lamb, who sailed as a forecaster in the whale factory "Balaena" during the 1946-7 whaling season—he found the reports of value to him, even when the ship was working in the Australian sector, 180° of longitude away (see *Meteorological Magazine*, April 1949). Eventually it is hoped that the service will be able to provide forecasts of practical value to the whaling fleets operating from the Dependencies. Forecasts have already been supplied with some success to the F.I.D. Survey Vessel "John Biscoe" and to H.M. Ships visiting the area.

Work is in hand to develop special instrumental equipment suitable for operation under Antarctic conditions. The instrument development section of the British Meteorological Office have already designed a 3-cup recording anemometer which, when coupled with the Desynn wind vane, will give records of wind speed and direction, and it is hoped eventually to develop a recorder for temperature and dew point (possibly using the principle of the Dobson-Brewer hygrometer.)

Staff too must be carefully chosen ; there are usually ample volunteers for work in the Antarctic but observers, in addition to being familiar with standard observational practice, now need and will be given the necessary training to maintain equipment. Life at a base is simple but satisfying : it provides an interesting job with many openings for the enthusiast and includes the practical work of running and maintaining one's own base. There are opportunities for helping with other scientific work such as marine biology and ionospheric measurements, and survey work provides interesting short journeys away from base. There are countless scenes to delight the amateur photographer. Thus the job provides new and interesting work combined with a hardy adventurous existence and an experience in human companionship which is rarely within the reach of the average meteorologist.

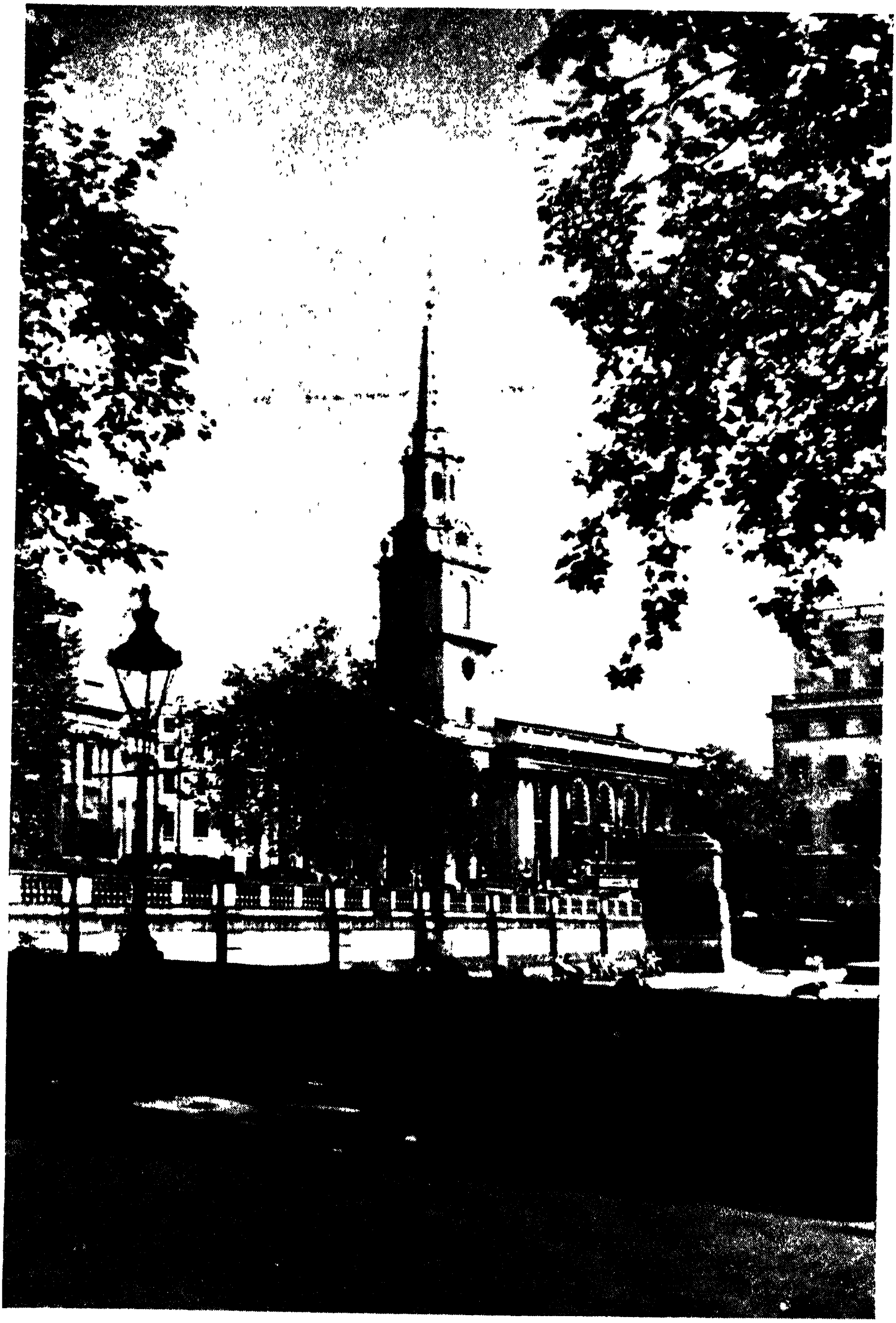
G. A. HOWKINS.

General view of Base A Port Lockroy

Pilot Balloon observation at Deception Island

By courtesy of] [*Colonial Office*

PLATE III



Solitary cumulus above St. Martin's-in-the-Fields

Photograph by] *John Mountford*

PLATE IV

LETTERS TO THE EDITORS

A single cloud in the sky

Occasionally, in the summer-time, a single small white cloud is noticed in an otherwise clear blue sky.

How can such a single cloud exist ? If the air surrounding it has a relative humidity approximating to 100% why doesn't the cloud increase ? If the air surrounding such a lone cloud has a lower relative humidity than 100% why doesn't it almost immediately absorb the lone cloud ? What causes the lone cloud to form and why does it last so long (comparatively) ?

Could any of your readers enlighten me on this phenomenon ?

Chicago, Illinois, U.S.A. FRED LICHTGARN

[An example of a solitary cloud may be seen in Plate IV. EDITORS]

Young French Meteorologists

Les Groupes & Foyers Météo, organisation des jeunes de la Météorologie Nationale, organisation fondée en Mars 1947, et régie par la loi du 1-7-1901, ont l'honneur de solliciter une liaison avec les jeunes de votre Service Météorologique.

Notre organisation dégagée de toute emprise politique, religieuse ou philosophique ne se propose d'autre but que l'élévation du niveau des connaissances de ses adhérents par des visites du musées, monuments, sorties théâtre, concerts, conférences, ciné-club, sorties camping, et par là, intensifer leur esprit de camaraderie et de solidarité.

Faire connaître les pays étrangers à ses compatriotes, c'est faire ambassade de son pays auprès de ses hôtes.

Groupes & Foyers Météo Siège Social, A. BROUSSE
196, rue de l'Université, Paris, VII Le délégué aux Relations Extérieures.

[Would any reader who is interested please write, in French or English, direct to M. Brousse at the address above.—EDITORS]

Soaring "Thermals" and Industry.

I was most interested to read the letter signed Donald L. Champion in the November issue of *Weather*, concerning convection cloud above Brimsdown Power Station, having experienced a similar phenomenon myself whilst soaring in Germany. It is possible that the experience which took place at 1630 G.M.T. on May 17, 1948 over the power station just north of the Ruhr, on the eastern bank of the Rhine just south of where the river Ruhr joins the Rhine, may be of interest ; the details (unfortunately largely from memory) are as follows : –

The circumstances were that I was at what looked like the end of a cross country flight in a sailplane (Weihe). Most of the day there had been steady thermals rising to the inversion level which was about 2,100 metres. There was no cloud at any time, and all the thermals had been "dry." By 1630, most of the thermal activity had died out, and apart from a few very insignificant bits of lift, none greater than a half metre per second, and none giving lift to more than 500 metres, the air was dead. These small, and rapidly dying thermals came from woods, and slag heaps, and I was looking for a place to land, when I noticed the power station, obviously taking up the evening load.

The power station produced the best thermal of the day, giving lift all the way up to 2,300 metres, where the lift died out. The greatest lift was at about 1,900 metres, where it reached, so far as my memory serves, about four metres per second. The thermal evidently had sufficient energy to break through the inversion at 2,100 metres, and the turbulence around the edges of the column of rising air, suggested that its top mushroomed out and then turned down in a series of down currents all round the mushroom head. After leaving the power station thermal, I found no other lift or thermal activity whatever, and flew in a perfectly straight glide to my destination at Geldern near the Dutch border, arriving there with considerable height in hand.

In order to get a true measure of the strength of the thermals from this power station, the figures given above should have added to them a further half metre per second, which was the sinking speed of the particular sailplane circling in still air at the particular speed used at the time.

No doubt you will be able to check the meteorological conditions at the time in case my memory has served me badly in giving the inversion height. You will no doubt recollect that at that time NW. Europe was covered by a layer of very dry air with light easterly winds.

Maxwell Field, U.S.A.A.F.,
Alabama, U.S.A. G. J. C. PAUL

"The Times" Weather Charts

I should like to support strongly the view Mr. Dines states in his letter in *Weather* of September 1948, which I have just seen. The forecasts are read both by the general public, most of whom do not understand any charts, and by meteorologists who would surely prefer to have the latest possible actual to any official forecast chart, since the latter can be deduced from a well-expressed *General Inference*. In the dark ages long ago the morning synoptic chart was delivered by post over much of the country without fail on the same evening, but now it appears on the following morning (if we are fortunate). The latest actual chart that the morning papers can publish would therefore be the more useful.

These prebaratics are hardly a good advertisement for the forecasters as inaccuracies show up too clearly ; a front drawn even 50 miles from its actual position—and larger errors have been noted—is seriously misleading, and though the weather sequence may be adequately forecast the timing is so incorrect that the forecast is useless. Such errors are inevitable in a prebaratic for about 12 hours in advance. The written forecast avoids any attempt at precise timing by using such words as "in the morning," "during the day," "at first," "later".

Another point in the form of the official forecasts : why is the term "front" always avoided ? "Trough of low pressure" is the favourite vague expression, but, by the uninitiated at any rate, the troughs can hardly be seen on most charts while the fronts with all their embroidery stand out boldly to catch all eyes. The public are more likely to understand wording in terms of fronts that they see than of almost invisible troughs. Or is the frontal theory not recommended officially for the people ?

Oxford W. G. KENDREW

In his *apologia* for the selection for publication by *The Times* of the forecast map rather than the map giving observations Mr. Gold makes little of the most important fact relative to the discussion. He says nothing of the fact that *The Times* publishes two forecasts, one in words and one in map form, but no data on which either is based.

Those of us who are dissatisfied with the present arrangement wish at least one map with observational data in addition to one forecast. Whether the latter, in map form or in words, is the more acceptable is a matter for investigation but I should imagine that the great majority would prefer the forecast in words. Of course if the forecast map were also published, a most interesting comparison would be possible between it and the *data* map published the following day.

London, N.11 J. FAIRGRIEVE

In the hope of shortening what promises to be an interminable discussion and so saving space in *Weather* for other subjects may I make an appeal to the logic of the case which, I submit, should over-rule personal predilections ? As the weather information given in *The Times* is not a report of past weather but a forecast of coming weather it is surely entirely consistent to express this cartographically as well as tabularly just as in the same way it is the common practise to convert statistical tables into cartographic and diagrammatic forms.

Hampstead L. C. W. BONACINA

Changes in the Climate.

Recent numbers of *Weather*, December 1948 and January 1949 have contained articles and correspondence on the subject of climatic change. We in Holland have had, in the last two years, a series of high monthly means of temperature. The winter of 1946-47, before this warm period, was very cold. February 1947 was, except for 1855, the coldest month in the last 240 years, the monthly mean temperature in February 1947 at our principal observatory at De Bilt being 8°C. below normal. March was also a cold month, especially the first half, but April 1947 was the first month of a long series with an average temperature above normal. This period with high averages has already continued for 18 months. During the period from April 1947 to February 1949, only three months had an average below normal (October 1947 –0.3°C., July 1948 –0.1°C. and November 1948 –0.3°C.). The average deviation over this period of 22 months, for De Bilt, amounted to +1.3°C. The largest deviation on this period was recorded at De Bilt in August 1947 as +3.6°C. A long period like this, with monthly temperature averages above normal, has seldom occurred in Holland. Is our climate gradually becoming warmer ?

Airport Eelde, Holland J. H. PELLEBOER

Airmet Interval Signals

If an interval signal is really necessary in the Airmet broadcasts, must it consist of sounds such as might be produced by the asthmatic owner of a battered old cornet after taking his third lesson ? Why not let the signal draw on music appropriate to the several seasons and give us, for example, the opening theme of Delius's " On hearing the first cuckoo in spring " from March to May, a few bars of the same composer's " Summer night on the river " from June to August, a passage out of Debussy's " Jardins sous la pluie " from September to November, and a little of Sibelius's magnificently shiverful prelude to " The Tempest " from December to February ?

Dagnall, Bucks. E. L. Hawke

A Ghost is laid to rest?

Mr. G. Bain Ross's suggestion (*Weather*, January 1949, page 32) that a revised reading of -19° F. be allowed to stand for the Blackadder thermometer reading of -23° F. on December 4, 1879, cannot pass unchallenged. It has been proved that the reading was taken under unsatisfactory conditions, which suffice to invalidate the observation from a scientific point of view. There have been frequent "records" claimed at various times, and it is essential to the interests of science that all that have not the true stamp of accuracy be omitted.

Further, the difference in altitude and the " closed " position at Blackadder are not sufficient to account for even a difference of 2° F. from that at Kelso, when such a remarkably low temperature is involved. As far as I remember, there has been no observation made to date to prove that the Blackadder temperatures are normally below those recorded at Kelso.

In the interests of scientific accuracy the Blackadder recording is better forgotten. It is no doubt unfortunate that this controversy has arisen ; in any case the value of an absolute minimum recorded is not of such great importance to meteorology that a slightly higher and entirely accurate one cannot be substituted. Only the romanticist will bewail the passing of the Blackadder myth, which may be consigned to the same place as the Loch Ness Monster and the fable of the enclosed glacier.

St. Andrews, Fife I. Rička Whitaker

Mr. G. Bain Ross's regret that the "famous Blackadder temperature" of -23° F. cannot justifiably be quoted, without qualification, as the lowest temperature ever recorded in Great Britain must have been shared by many readers. So far as actually recorded temperatures are concerned, however, the appended extracts cannot but clinch the matter for those authors of text books, published articles or broadcasts who accept Meteorological Office criteria.

Journ. Scott. Met. Soc. LXIV p.73, Report of half-yearly general meeting on 21st July, 1880 :—" Since the last half-yearly meeting Mr. Buchan has inspected the Society's stations at Thistlestane Castle, Bowhill, Galashiels, Springrood Park, Paxton House, Eyemouth, Blackadder and Marchmont."

Report of meeting on 25th February, 1881, p. 80:—" Mr. Buchan explained that the thermometer at Blackadder, by which a temperature of -23°.0 had been recorded, was an exposed one and could not be taken into account in making comparisons with other places."

Barnton, Midlothian W. A. Harwood

Changes in the Climate of London

I am grateful for two letters in the December issue which correct an error in my letter of September, 1948. Although the writers arrive at two different values of χ^2, it is clear that Mr. Hawke's remarks (April, 1948) on this subject can now be regarded as substantiated. With reference to his letter of December, however, I may say that there was no desire on my part to question his " facts " (the observed number of rain days) but only the significance to be attached to them.

It appears then that the climate of London in one respect at least has changed significantly since 1669-89. This raises the question as to when, and over what period, the change took place, or whether there has been more than one variation of type. Moreover, a detailed statistical investigation (as indicated by Mr. v. d. Bijl) of such small but nevertheless important changes as may have occurred since regular observations became available might well throw some light on the general problem of the cause of climate variation, and even on the trend of weather in the future.

London, N.10 A. F. Crossley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This Radiosonde was developed by Salford Electrical Instruments Ltd., in conjunction with the Met. Office, and is being manufactured in large quantities. It comprises a radio transmitter which is modulated alternatively by an audio-frequency which depends upon the temperature pressure and humidity. The met. elements have been chosen for their stability and cyclicity, and its results are better than any similarly priced instrument in the world
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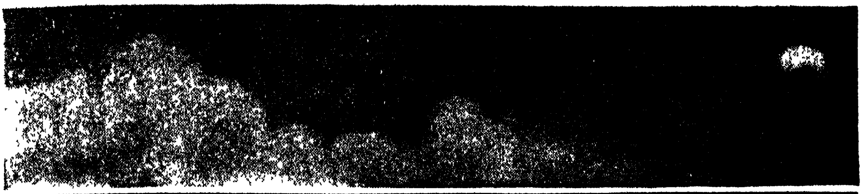

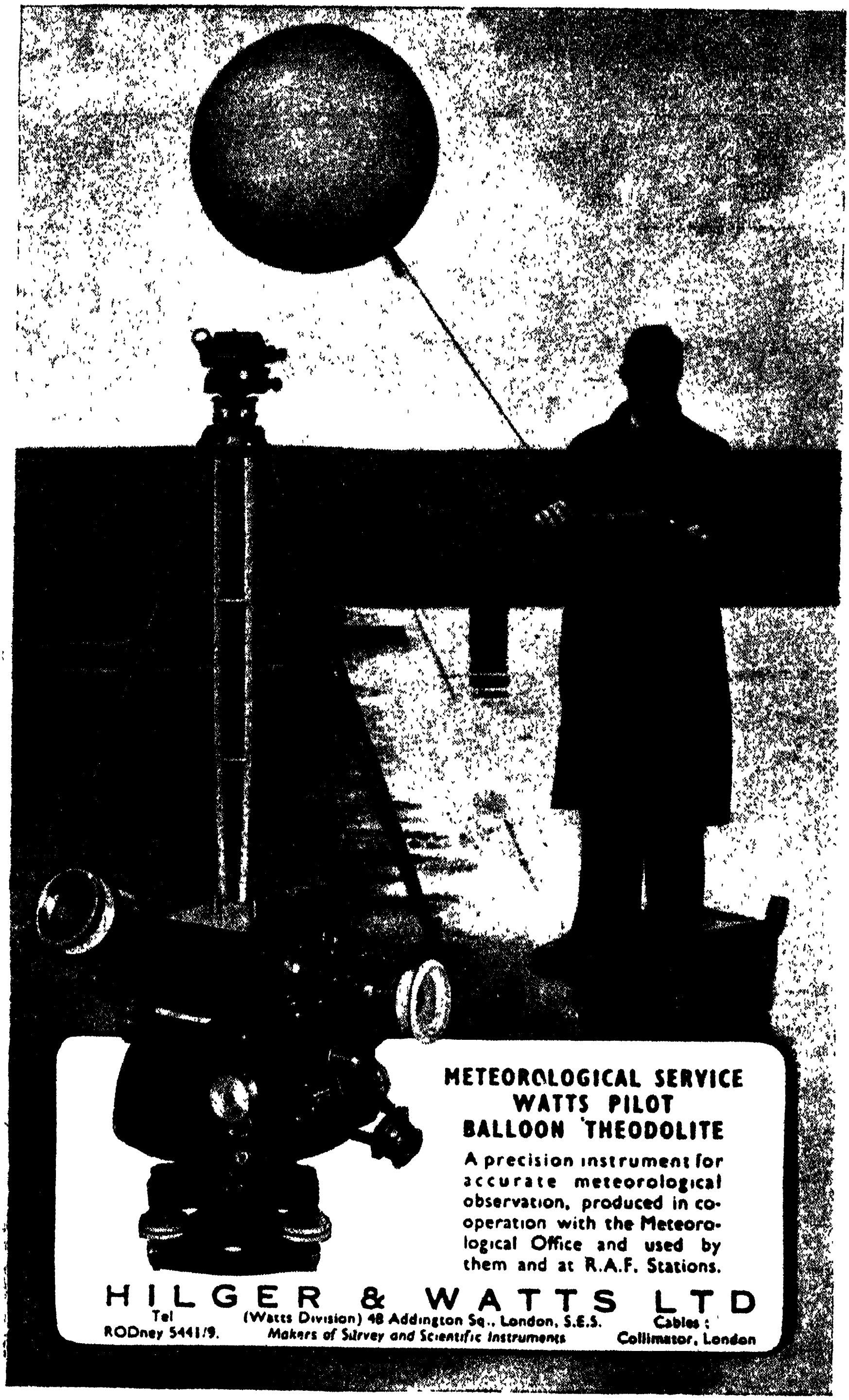
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JUNE 1949

WEATHER

Vol. IV No. 6

CONTENTS

EDITORIAL

The use of rockets for high altitude research is a natural development consequent on the reaching of the limits imposed by the use of balloons or aircraft. In case the impression should be gained that the way is now open to extend our field of research to even greater and greater heights, it seems worth while to draw attention to some of the difficulties involved.

Considerations of weight alone place a limit on the use of chemical fuels. For example, the velocity of escape from the earth may be taken as 36,000 feet per second and the most energetic chemical propellant is unlikely to give an exhaust velocity exceeding 1100 feet per second. Ignoring gravity and air resistance a simple calculation shows that a rocket of total weight 28 tons would have to include 27 tons of fuel in order to attain the escape velocity by straightforward exchange of momentum. If gravitational and frictional forces are taken into consideration, the project is not an engineering possibility.

It may be asked what are the possibilities of using atomic energy and developing a rocket which uses nuclear fuel. On energy considerations alone the problem appears capable of solution but on closer examination other difficulties appear. It has been pointed out by the American scientist E. P. Wigner that, for a given efficiency, heat must be removed if vaporization of the rocket is to be avoided. While, in the lower atmosphere this is done by convection, at greater altitudes radiation is the only natural heat removing process and this is likely to be inadequate.

In his article on page 176, D. D. Clark discusses the considerable progress in rocket research being made in America ; but the enormous expense will place severe limitations on its development. Meteorologists must possess their souls in patience for many years before they can hope for the rocket sonde to become an everyday plaything.

ATMOSPHERIC ELECTRICITY DURING THE LAST 50 YEARS

* By Sir George C. Simpson, F.R.S.

" All these speculations were however cut short by an epoch-making discovery made in 1899 by C. T. R. Wilson in England and by Elster and Geitel in Germany. They found that the atmosphere in its natural state is *ionized* ! The degree of ionization was not great, but it was sufficient for an insulated charged body to lose five per cent of its charge each minute."—*Remark made during lecture.*

PART III. CAUSES OF ATMOSPHERIC IONIZATION

During the three years after Elster and Geitel and C. T. R. Wilson discovered the natural ionization of the atmosphere a great deal of work was done, chiefly in Germany, on measuring the ionization and its daily and annual variation. But the cause of the ionization was not yet clear. There were a number of possibilities :

(1) It was known that the rocks and the atmosphere contain radio-active matter ; but whether there was sufficient to have any appreciable effect was not known.

(2) It was known that X-rays and ultra-violet light can ionize air, but it was not known whether ordinary daylight could do so.

(3) It was also known that the gases in flames are highly ionized ; perhaps there might be some residual ionization due to molecular motion at atmospheric temperatures, and if so the ionization should depend on the temperature.

(4) The aurora was believed to be due to electrical discharges in the upper atmosphere, and there were many reports of auroral rays penetrating to the surface in high latitudes : could the ionization at the surface be due to the same cause as the aurora ? If so, there should be a large latitude effect, and great activity of the aurora would be expected to be accompanied by increased ionization at the surface.

It was while pondering on these questions in Göttingen that I realized how important it was to obtain full observations of the electrical state of the atmosphere in polar regions. In the first place the long period of continuous sunlight in the summer, and the long period with the sun always below the horizon in the winter, would solve the question of the effect of daylight ; a comparison of the ionization at low polar temperatures with that at European temperatures should settle the temperature question ; and finally if the aurora is important its effect should be recognizable where the activity of the aurora can be compared directly with the ionization. I made some enquiries and six months later I found myself in the Lapp village of Karasjok, three degrees within the Arctic Circle.

I stayed in Karasjok nearly 13 months, during which I obtained a complete year's observations on the potential gradient, the ionization, and the radio-

* From a popular lecture to the Royal Meteorological Society on January 12, 1949, summarized by A. R. Meetham, D.Sc., Parts I and II appeared in *Weather* of April and May, 1949.

activity. The results were quite clear: neither the amount of sunlight, the temperature, the amount of radioactivity, nor the aurora, had any measurable effect on the ionization. Tests at Hammerfest, on the coast, showed that air from the land contains at least ten times as much radioactive emanation as air from the sea, thus confirming that the radio-matter in the air originates in the rocks of the land. On the other hand, the ionization was connected with the clearness of the atmosphere. The conclusion was drawn that there is a constant ionizing factor, and the changes in ionization are due to changes in the rate of recombination of the ions—which was known to depend on the clearness of the atmosphere. But my measurements in the Arctic gave no indication of the ultimate cause of the ionization.

PENETRATING POWER OF THE IONIZING AGENT

During this time much work had been done elsewhere to find the cause or causes responsible for the natural ionization of the atmosphere. The amount of ionization in the air at any one time depends on two factors: (a) the number of ions being produced each second, and (b) the number of ions which combine into neutral molecules each second. Between the two, a steady state is reached which determines the number of ions actually present. For discovering the cause of the ionization we are interested in only (a), the number of ions formed each second. The usual procedure was to take a closed metal vessel, generally made of thin sheet zinc, chemically pure and free from all radio-active matter. Whenever a molecule within the vessel is ionized, a positive and a negative ion are produced, so the ions are always produced in pairs; and it is usual to describe the intensity of the ionization by the number of pairs of ions produced in each cubic centimetre in each second.

When such a vessel was observed it was found that the ionization varied very much from time to time and from place to place, and it was concluded that this was due to the radioactive matter in the soil and the air. The next step was the obvious one of surrounding the vessel with thick masses of material, capable of absorbing the most penetrating rays from radioactive matter. When this was done there still remained a residual ionization, which the most refined modern measurements make about one pair of ions per c.c. per second.

VARIATION WITH HEIGHT

The next problem was to see the effect of height on the ionization. One of the thin-walled ionization vessels was raised from the ground to the top of the Eiffel Tower, 300 metres. On the ground the ionization in the vessel was largely due to gamma radiation from the radioactive rocks. This radiation is absorbed by the air, and Eve calculated that 90 per cent would be absorbed at the top of the Tower; but the observations showed a reduction of only 40 per cent. Observations on other towers and on mountains showed the same unexpectedly large values of the residual ionization. It was obvious that observations must be made in balloons.

The first observations in balloons, in 1909-11, were unsatisfactory; but they showed some decrease in ionization up to about 3 kilometres. In 1911-12 Hess, using improved instruments, made ten ascents, some up to 5 kilometres, with

surprising results. He confirmed the slight decrease to about 1,000 metres, but found that from there upwards the ionization commenced to increase—at first slowly, then rapidly—so that at 5 kilometres it was several times greater than on the ground. He concluded that there was a penetrating radiation coming downwards in the atmosphere.

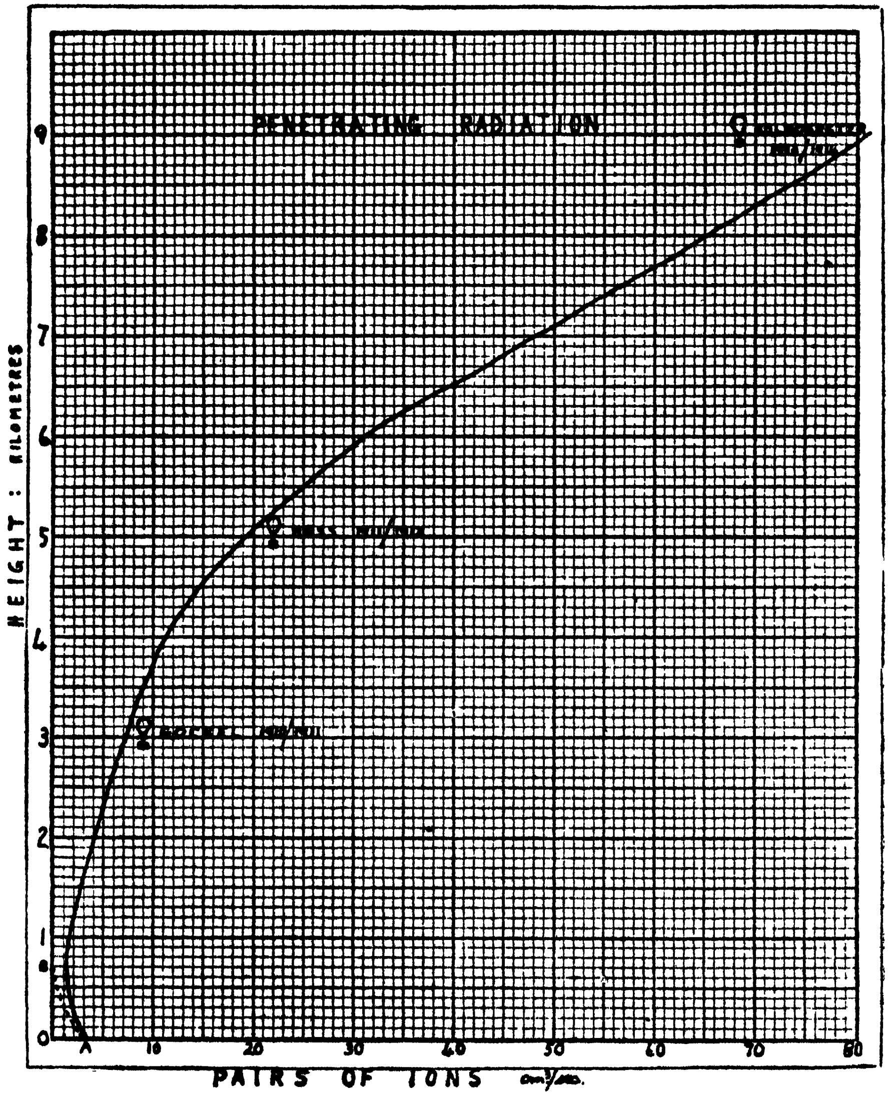


Fig. 7. Increase of ionization with height

Still greater heights were reached by Kolhörster in 1913. He made five high ascents in which he confirmed Hess's results, and carried the observations to 10 kilometres where the ionization was so great that there could be no doubt of the increase of ionization with height. The results of these observations are shown in Figure 7, which shows the number of pairs of ions generated per second

in a cc. of air at standard pressure, after all corrections have been applied.

This result was entirely unexpected, and leaves no doubt that in the upper atmosphere there is some ionizing agent which is many times greater than anything near the surface. At first there was much argument as to the nature of this ionizing agent, some saying that it was not real but due to faulty instruments and methods, others suggesting that there was an intensely radioactive gas in the upper atmosphere ; but it was soon generally accepted that it was a very penetrating radiation coming into our atmosphere from the outside, and it was given the name of *cosmic radiation*.

COSMIC RADIATION

The decreasing ionization from the upper atmosphere towards the ground is obviously due to the absorption of the radiation by the air. It is possible to calculate from the shape of the curve the absorption coefficient of matter for the cosmic radiation and it was found to be fifteen times smaller than that for the hardest gamma-radiation from radioactive matter. Hence the cosmic radiation is extremely penetrating, and in fact it is not completely absorbed by the whole atmosphere, there being an ionization of 1 ion per cc. per second at sea level due to cosmic radiation, although the absorption of the atmosphere is equivalent to a screen of mercury 30 inches thick. This position was reached in 1914, but practically no one outside a few meteorologists interested in atmospheric electricity knew anything about it ; then the first World War broke out and the work came to a standstill. In 1916 I was in India, and felt it was important that the attention of physicists at home and in America should be drawn to this important work which had been done entirely by Germany ; so I wrote a letter to *Nature* summarizing the results and suggested that as England and Germany would be in no position to do any ballooning for some years to come, America, who was not then in the war, should continue the work. Nothing happened. It was not until about 1930 that the physicists really became aware of the implications of this new cosmic radiation. When they did, discoveries were made which stand comparison with those of the electron and radioactivity.

It is not my intention here to describe this work of the physicists. Suffice it to say that the origin of the rays was found to be in the depths of the cosmic space and probably in the nebulae distributed throughout space, far beyond the limits of our own galaxy. The rays themselves, at first thought to be of the nature of ultra-short wave radiation, were found to be protons, nuclei of hydrogen, moving with incredible velocity, and quite recently nuclei of other elements have been detected. These moving material particles carry with them abnormal amounts of energy : while the most energetic particles we know on earth, produced by radioactive matter, have an energy of 300 million electron-volts, the particles of the cosmic rays have the energy of a million million electron-volts, and are therefore the most powerful atom-smashing agents that man has yet discovered. They also led to the discovery of the meson, an entirely new elementary particle, comparable with the electron and the proton.

This is by far the greatest gift of the meteorologists to the physicist; for the discovery of the penetrating radiation was the unaided work of meteorologists examining the properties of the atmosphere. And we meteorologists are pleased to hand over the further study of these foreign particles which, so far as we can see now, have no influence whatever on the weather which is the subject of our science.

TOP OF THE ATMOSPHERE *

149 pages, 44 figures, 45 tables
Rand Corporation $2.85

By G. Grumminger
Santa Monica, Cal.

The "analysis of temperature, pressure and density of the atmosphere extending to extreme altitudes" was undertaken by Mr. Grumminger to provide the United States Air Force with information needed for evaluating the performance of very-high-speed high-altitude rockets. His very interesting monograph (in roto-type) contains many tables and figures for the state of the atmosphere over the equator and the middle latitudes, a full list of references, and some speculative calculations about a region where angels literally might feel at home, but metaphorically would certainly fear to tread.

Up to 100 km. or so, the author agrees fairly closely with the NACA atmosphere, which has a minimum temperature between 10 and 30 km., a maximum of 350°A. at 50-60 km., and another minimum of 240°A. at 80 km. Above 100 km. to the height of the F_2 layer at about 300 km., ionosphere measurements indicate a rise of temperature and, selecting from estimates varying from 373°A. to 2,000°A., Mr. Grumminger chooses 1,100°A. as the most probable temperature of the air at 300 km.

For the sake of the tables which he calculates, he assumes the composition of the atmosphere to change between 83 and 120 km., where the oxygen molecules dissociate into atoms and the proportion of oxygen (by volume) rises from about 20 per cent to over 30 per cent. Already, above 100 km., the atmosphere has become a fair approximation to a vacuum, and temperatures and pressures signify little more than the average motions of individual molecules ; the mean free path of a molecule is greater than the length of a rocket.

Above the F_2 layer the atmosphere still exists and contains nitrogen and oxygen, because aurorae extend as high as 1,200 km., but what can be said about the gases there ? The degree of uncertainty may be visualized from the suggestions that the composition may be anything from pure ionized hydrogen to neutral atomic nitrogen, and that temperatures ranging from 1,800°A. to 10,000°A. are feasible. Mr. Grumminger makes three tentative "models" of this region, (i) in which the atmosphere merges into the interstellar gas, (ii) in which the molecules move as free bodies in the earth's gravitational field, and (iii) which is a mixture of (i) and (ii). He takes the interstellar gas near the

* Review of "Analysis of Temperature, Pressure and Density of the Atmosphere extending to extreme altitudes".

planet earth to be mainly ionized hydrogen with a concentration of 1 atom per cubic centimetre.

The height at which the atmosphere finishes is different for each model. The concentration falls to about 5 molecules per cc. at a height of 5,500 km. in model (i), 2,000 km. in (ii), and 7,000 km. in (iii). Even a very-high-speed rocket is not going to be disturbed by 5 molecules per cc.

Although none of the models is likely to be very near the truth, no criticism of Mr. Grumminger's bold assumptions would be worth while, without producing a treatise showing that some alternative method leads to more useful results. Bridge players have a maxim that one peep is worth two finesses and for their purposes this is a fairly accurate statement of average values. There are so many ways of going wrong about the upper atmosphere, however, that one peep would be worth a hundred finesses. It can safely be foretold that information provided by the rockets themselves will reduce much of the book to no more than historical interest.

A.R.M.

OBSERVING THE WEATHER*

Now that so many schools and societies are equipped with 35-mm. projectors, film strips are gradually replacing lantern slides as a means of illustrating lectures. Strips are much cheaper to make and are more convenient to handle in every way ; breakage is eliminated and the most incompetent operator can hardly so mismanage things as to project the pictures the wrong way round or in the wrong order. Those who wish to make their own film strips will find much useful advice in an article by C. H. Bailey in the October 1948 issue of *The School Science Review* but for others, who prefer to buy their goods ready made, several firms are producing film-strip lectures on almost every suitable subject. *Observing the Weather*, produced by Rendell and Wilson of Hale and edited by E. P. Boon, M Sc., of Sheffield University, is a strip containing 30 pictures illustrating the work at a typical Meteorological Office outstation—Ringway Airport. The photography is excellent throughout, but even with such a high standard of comparison the pictures of meteorological instruments are outstanding for their clarity of detail and aesthetic appeal.

Brief notes describing the pictures are contained in a booklet supplied with the strip. The lecturer is rightly left to fill in the details, but some would no doubt welcome the addition of a short bibliography. The strip is more or less limited to showing the technique of weather observations ; it could well be followed up with further strips showing cloud classification, the basis of elementary forecasting and unusual weather phenomena. The treatment is fairly complete, although the omission of any reference to radio-sonde work might be remedied in a future edition. The film strip deserves to be widely used for educational purposes. The price, complete with notes, is 12s. 9d.

O.M.A.

* Review

Erratum

Weather, May 1949, p. 150 ; the price of the book *The Elements Rage* should have been quoted as 10s. 6d., *not* 1s. 6d.

HIGH ALTITUDE RESEARCH WITH ROCKETS *

By D. D. Clark, M.A.

The history of upper atmospheric research is largely taken up with the development of devices for carrying instruments to great altitudes. Kites, which were first used had the advantages of fixed, known location, and of being easily retrievable, but were severely limited in altitude. Balloons were able to reach much higher altitudes and could be designed to carry light recording apparatus—the existence of the stratosphere was first discovered by this means (see *Weather*, Jan. 1948, page 2). They could not, however, be used for rapid measurements, since records could not be analysed until the balloon had been found and returned—a very long and uncertain process. Not until the advent of the radio-sonde could measurements in the vertical be made and be available on the ground almost simultaneously (see *Weather*, May 1946, page 21). For most purposes in meteorology the balloon reaches altitudes which are sufficiently great but, for some special purposes such as research in cosmic rays or solar spectroscopy, greater altitudes are required. At present the only means of reaching greater altitudes is the rocket, a projectile carrying its own means of propulsion. Theoretically, there is no limit to the height which a rocket can reach, given sufficient propulsive power. The step from the rocket to the rocket-sonde however raises great problems of instrumentation and before the experiments on upper atmospheric research could begin, the problem had to be solved of how to make the required measurements from a projectile under conditions of extreme vibration and acceleration while travelling at speeds many times faster than sound.

Early in 1946 a section of the American Naval Research Laboratories began rocket-sonde experiments at White Sands, New Mexico (Lat.41°N.) by firing off German V2's carrying instruments ; the ascents continued at approximately fortnightly intervals for a year. The warhead was replaced by a conically shaped part consisting of three sections, in which most of the instruments were housed. The automatic fuel cut-off was removed so that the motor would continue to operate until the fuel was exhausted, and to obtain greater maximum height on the trajectory, the rocket was launched at a much smaller angle to the vertical.

The V2 is 46 ft. long, 5½ ft. in diameter, weighs 28,000 lb. loaded, and is capable of carrying some 200 lb. of instruments to heights exceeding 150 km. It is, however, expensive and complicated to operate : after the motor ceases to function at about 30 km. altitude, there is no longer any stabilisation —control being provided by carbon vanes in the exhaust jet— and the rocket can roll and yaw, which complicates the instrumentation.

* From a contribution to the Meteorological Office Discussion on Nov. 29, 1948. It was based on *U.S. Naval Res. Lab. Reports* No. R–2955, R–3030, R–3120, and R–3171, published in 1946 and 1947 ; and Krause, E.H. " High-altitude research with V2 rockets" *Proc. Amer. Phil. Soc.*, Philadelphia, Pa., Vol. 91, p. 450 (1947).

The range of pressure measurements, from about 10^{-3} mm. to 10^{-5} mm., necessitated three different kinds of apparatus. At low levels, for pressure above 10 mm., measurements were made with a conventional bellows-type barometer. In the range of pressures from 10 mm. to 10^{-3} mm., a Pirani gauge was used ; this depends for its operation on the variation in the conduction of heat in a gas with changes in pressure. A platinum or tungsten filament is heated by a constant electric current, and variations of pressure cause corresponding inverse variations in filament temperature which, in turn, are accompanied by variations in its electrical resistance, the latter being used to measure the pressure. For pressures from 10^{-3} to 10^{-5} mm., Pirani gauges are not effective, and ionization gauges were used. In these gauges electrons from a heated filament are accelerated towards a collecting electrode and the positive ions formed on the way are collected on a third electrode. The ion current varies with the pressure, the relationship being linear if the emission is less than 5 ma. The particular type used in the V2 experiments is known as the Philips gauge ; the electron path is increased several hundred times by a magnetic field across the tube which makes the electrons move in spirals, and results in a greatly magnified ionization current.

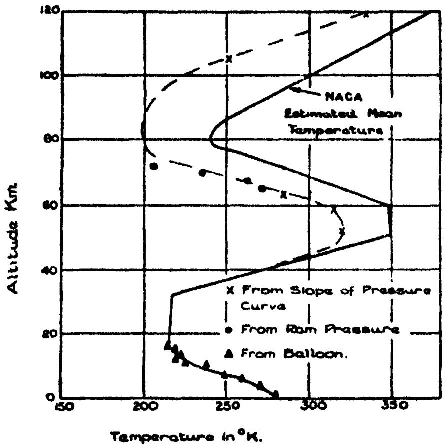


Fig. 1. Temperature variation with height.

Pressures were measured with these instruments at the leading tip of the rocket (ram pressure), on the side of the war-head cone, and at a point on the body in front of the tail fins. When corrected for the aerodynamic flow caused by the speed of the rocket, pressure readings taken in this manner were found to agree closely with ordinary radio-sonde measurements up to the limit of the ascent, except at one point where the speed of the rocket passed that of sound. These formulae can be used at heights up to about 80 km., above which the term "speed of sound" no longer has any meaning, being replaced by "the most probable speed of the air molecules". Above about 100 km., however, new formulae based on kinetic theory become applicable. The intervening

20 km., is a no-man's-land for which no suitable method of deriving atmospheric pressure and temperature from the measured values is suggested.

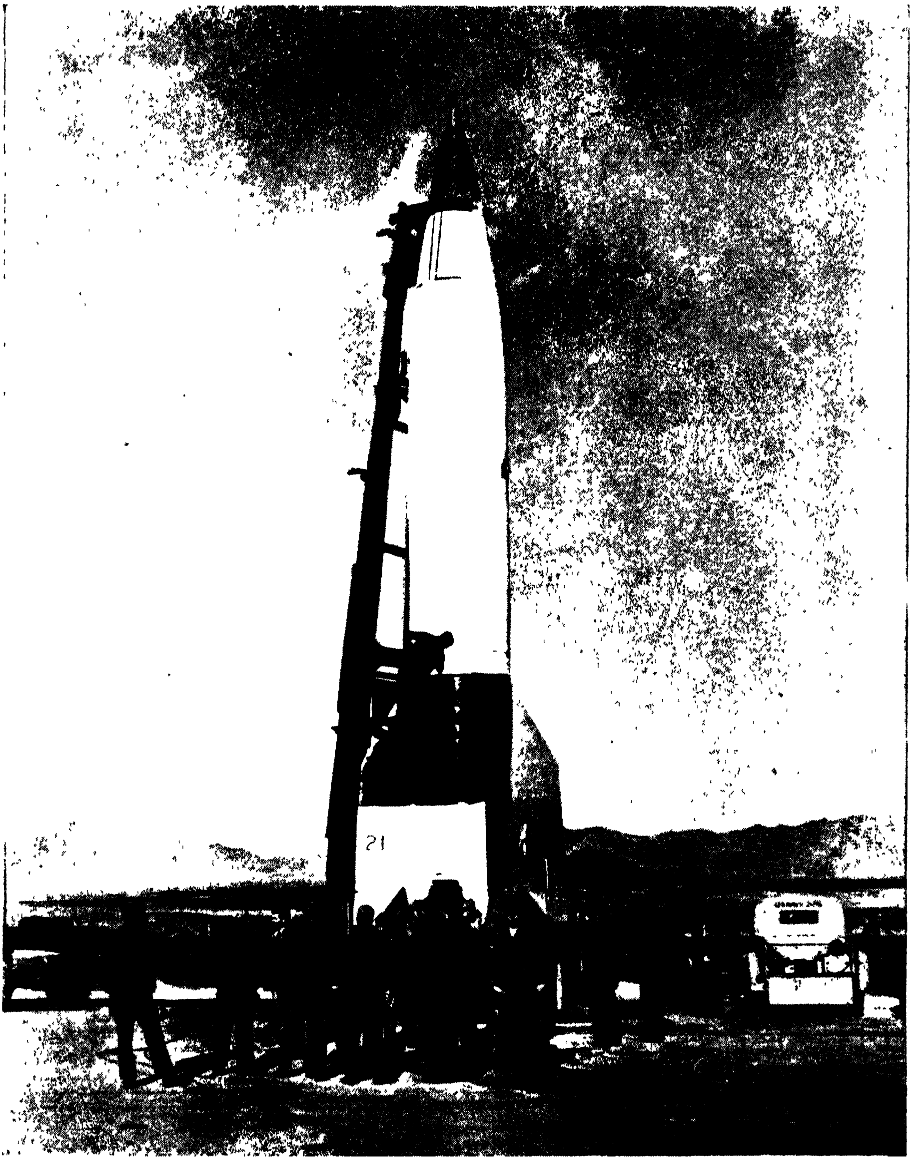
Although temperature-measuring elements were mounted on the rocket to obtain skin temperatures or to measure temperature changes in the instruments, no direct measure of atmospheric temperature from the rocket was attempted. Values were deduced along with atmospheric pressure from pressures measured at the leading tip and on the sides of the vertical cone, and temperatures were also calculated from the slope of the pressure-height graph. Temperature values obtained by this means are shown plotted against altitude in Fig. 1. The significant features of this graph are the maximum at 50 km., the minimum at 80 km., and the steady rise above 100 km., which agree with the latest theories on upper atmospheric temperature distribution. The curve calculated by the National Advisory Council of America from data available from other sources is shown in the same diagram for comparison.

Proposals were also made to obtain temperature from measurements of the velocity of sound at different levels ; this was to be accomplished by detonating charges at 10,000 ft. intervals, which would be observed from the ground. The time lag between the flash and the sound of the explosion as observed at a ground station would give the average velocity of sound over that path. If this measurement were made for each level the average velocity of sound over each 10,000 ft. interval would be obtained, for which the corresponding average temperature could be calculated. Another novel method which was suggested was to create artificial meteorites by launching grenades filled with metal pellets ; after explosion, some of the pellets would attain speeds great enough to resemble meteorites, and by observing such artificial meteorites with cameras at ground stations, it would be possible to deduce values for the temperature and the air density.

OZONE AND SOLAR RADIATION

The presence of ozone and molecular oxygen in the atmosphere result in the sun's ultra-violet radiation below 2900 A.U. being absorbed before it reaches the earth's surface. Ozone has a maximum concentration at about 25 km., but extends up to about 50 km.; molecular oxygen exists up to about 80 km., above which height it gives place to atomic oxygen. If photographs of the solar spectrum could be obtained above 100 km., the previously unknown part of the solar radiation would be recorded and important information obtained about the nature of the sun's emission. The same technique could also be used to give the distribution of ozone with height for comparison with other methods.

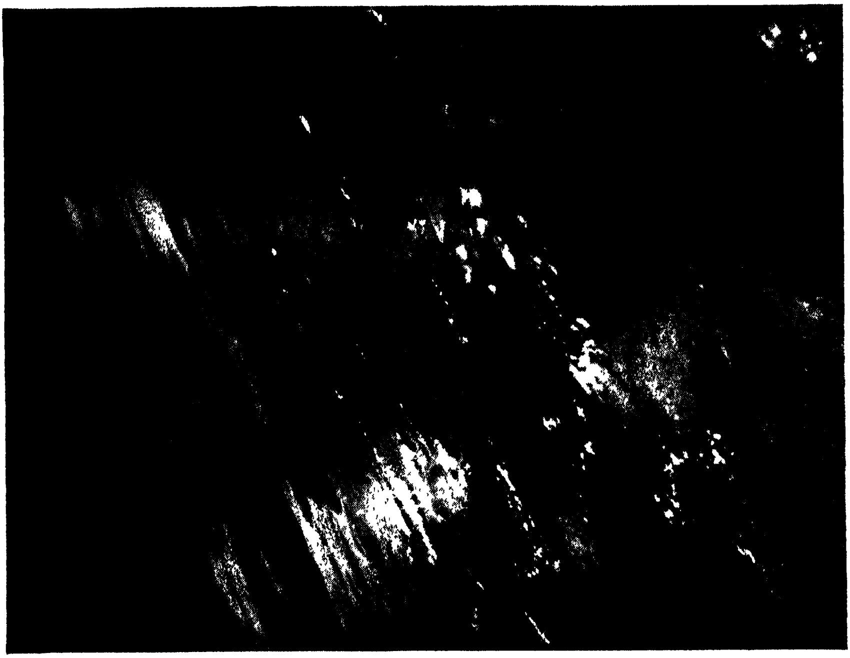
The study of the solar spectrum in the range from 2100 A.U. to 2800 A.U., was made possible by the construction of a spectrograph of unorthodox design. Since the short ultra-violet rays are easily absorbed, no lens systems could be used, and since the rocket was likely to rotate in flight the spectrograph had to be designed to record for all positions relative to the sun. A wide angle of vision and a very high maximum illumination was achieved by replacing the conventional ground-glass plate and slit with two small beads of lithium



A V-2 Rocket on its launching platform

By courtesy of] [*U.S. Naval Research Laboratory*

PLATE I



Photograph from a height of 101 miles. Note the Gulf of California at the top left

The earth from a height of 85 miles. The White Sands region is in the right centre

By courtesy of] [*U.S. Naval Research Laboratory*

PLATE 11

fluoride which gave point images of the sun. These beads were mounted on opposite sides of the spectrograph with their optical axis at 45° to each other ; each had an angle of view of 140°, so that the two fields of vision overlapped. The image from each bead was reflected on to a concave mirror of 40 cm. radius of curvature engraved with a grating of 15,000 lines to the inch. The astigmatism of the grating converted the point image of the sun into a line spectrum which was photographed on a 35-mm. film. A small electric motor wound on the film, and as each exposure was made, the film was arrested and a signal trans-

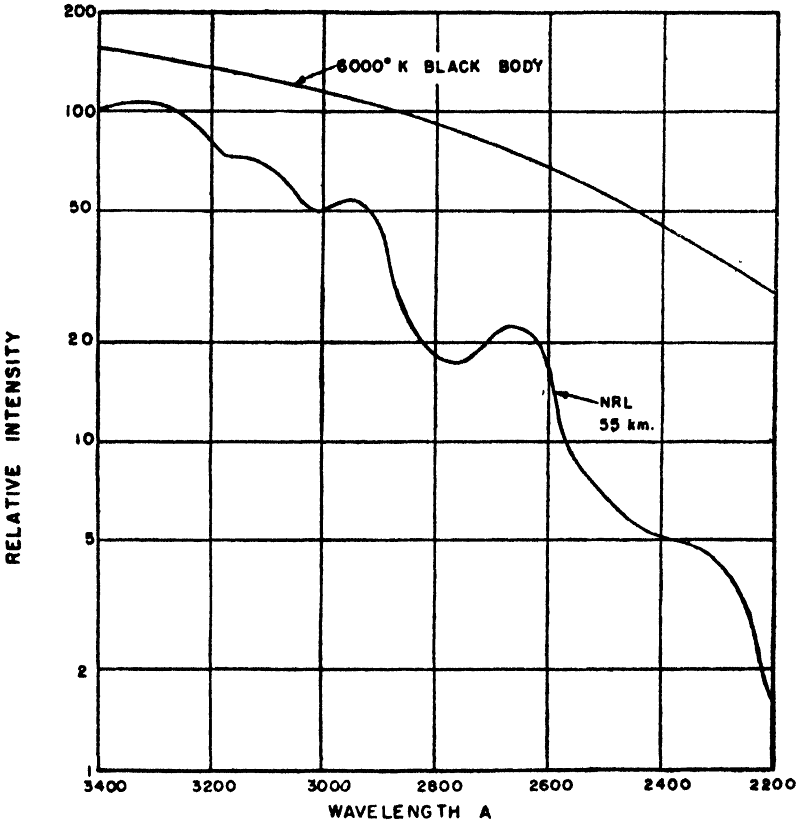


Fig. 2. Ultra-violet solar spectrum

mitted to the ground station so that the exact height of each observation could be obtained by comparison with the tracking data. The film was finally wound into an armoured container where it was preserved until recovered after the flight. As wave-lengths less than 2200 A.U. are absorbed by ordinary gelatine emulsions, the photographic emulsion was coated with a preparation which absorbs ultra-violet and becomes fluorescent in the visible and near ultra-violet. At very low pressures, electrostatic discharge might occur from the film and fog the records; precautions were therefore taken by backing the film with a black conducting surface.

Some excellent photographs were obtained with this instrument as a result

of which the curve of average radiant energy, as a function of wave length, was extended from 2900 A.U. to 2200 A.U. It was found that the ultra-violet intensities are much less than had been predicted by taking the sun as a black body of 6,000° K. (see Fig. 2). The analysis of the line widths and intensities which are important in determining the excitation conditions in the sun had not been completed when the reports on the first year's work were published.

By comparing the spectra taken at different levels, the absorption from one level to the other can be obtained and the concentration of ozone determined. Results by this method agree with other observations. For example on one occasion, Oct. 10, 1946 (see Fig. 3), maximum concentrations were found at 17 km. and at 25 km. Above 30 km. the concentration decreased rapidly and vanished within experimental error at 50 km. A graphical integration gave the total ozone content as 2·7 mm. Double maxima of this type have been reported before and it is generally agreed that the upper maximum is the

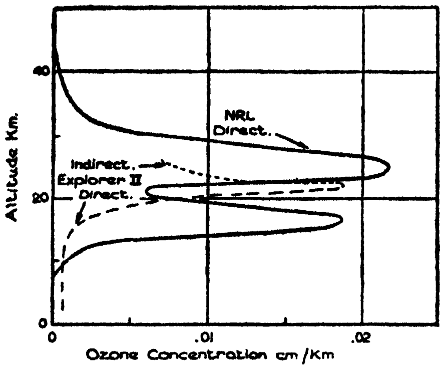


Fig. 3. Vertical distribution of ozone

principal one and that the lower is due either to diffusion downwards of ozone, or else to transport of ozone from other latitudes. The total concentration on this occasion agreed well with other observations taken nearby on Table Mountain, just before and just after the flight, of 2·5 and 2·7 mm. respectively.

THE IONOSPHERE

The ionosphere does not lend itself to such clearly defined methods of attack. When radio waves pass through the ionized layers they suffer refraction to a greater or lesser degree depending on their wavelength. Each layer has associated with it a critical wavelength depending on the maximum ion density of that layer. Signals of longer wavelength than the critical are totally reflected ; those of shorter wavelength pass through, but if they are only a little shorter they suffer greater retardation than if they are much shorter.

It was hoped to find some means of measuring ion density at all points of a region instead of just the maximum values for the layers. The method chosen was to select two wavelengths, one of which was just less than the critical for that day, and the other so much less as to be virtually unaffected by the ionized layers. To simplify the working out, the longer wavelength was chosen to be an exact multiple of the shorter. A transmitter on the rocket

broadcast steady signals on the two frequencies from trailing aerials ; the lower frequency when received at the ground station was multiplied to give it the same value as the other, and the two compared. The effect of the differential retardation in the ionosphere is to put the two signals out of phase with each other. An approximate relationship can be deduced giving the ion density in terms of the rate of change of the phase signal, but the calculations and measurements involved are lengthy and laborious and so far no important results have been reported.

COSMIC RADIATION

One of the most important fields of research was in cosmic radiation ; it was hoped that, by means of the rocket, the primary particles of this radiation could be studied directly as they enter the atmosphere above 100 km. It was also hoped to obtain some idea of the nuclear reactions which they initiate. For this purpose banks of Geiger counters were mounted in the head of the rocket, and the penetrating properties of the rays were investigated with thickness of lead, varying from 2 cm. to 14 cm. It was found that above 100 km., 35% of the rays were stopped by either 2 cm. or 4 cm. of lead, and could not be primary particles, presumably. It was suggested, however, that they might be electrons which arose from the atmosphere below through meson decay and arrived in that region after spiralling round the earth's magnetic field. The remaining 65% of the rays penetrated 4 cm. of lead, some producing showers. From the proportions which penetrated the other thicknesses it was deduced that, if all the radiation passing through 6 cm. of lead is primary, then not more than 14% of the primary is electrons ; of the remainder, 18% of the primary is absorbed in 12 cm. of lead. It was also discovered that the ratio of total radiation in free space to that at sea level was 11·5:1, while the ratio of the hard component in free space to that at sea level was 9:1.

RETRIEVING THE DATA

The problem of retrieving the data observed by any measuring instrument was solved in two ways ; in one, the measurements were transmitted by radio to ground, and in the other they were recorded in the rocket, the record (usually on a film) being protected in a robust container from which it was salvaged after the flight. The first method, known as telemetering, employed a time-modulated pulse system of frequency 1000 Mc/s with a power output of 3 kw. In this system the instruments presented the data in the form of representative voltages, from 0 to 5v. These voltages were then applied to a pulse-emitting circuit to control the spacing between individual pulses, the length of the spaces being proportional to the applied voltages. On being received at the ground station these signals were reconverted into the characteristic voltages and recorded on an oscillograph. In the original system there were twenty-four pulses to a group which meant that there were twenty-three spaces, that is twenty-three channels whereby items of data could be transmitted. Each of the pulses had a duration of only a few micro-seconds, while the spacing varied between fifty and two hundred micro-seconds. The whole set of twenty-four pulses was repeated some two hundred times a second, which means that if the

rocket were travelling at 1600 metres a second a measurement would be recorded for every 8 metres of its path. In a later model the number of channels was increased to thirty. The two channels allotted to the transmission of pressure and temperature were each further sub-divided by a commutator into fourteen sub-channels, which enabled several gauges to be connected to the same channel. Provision was also made for calibration and time marking. The accuracy of this set was expected at first to be $\pm$ 5% of the range, but this was later improved to $\pm$ 1%. Loss of voltage at the low pressures was prevented by pressurisation, the whole transmitter being enclosed in a sealed chamber.

The second method of data recovery, depending on the salvage of the records after the flight, was accomplished successfully by exploding the rocket into three parts which, offering greater resistance to the air than the undivided rocket, fell at reduced speeds and were not utterly wrecked on impact. The spectrograph was installed in a tail fin which allowed an almost unrestricted field of view besides providing good protection, while the cameras were mounted on the main body.

Although, perhaps, the time has not yet come when rockets can be regarded as a routine method for upper atmospheric observations, it can nevertheless be accepted that the rocket-sonde has at least become a reality. The first trials of this kind at White Sands, New Mexico, have been attended by the growing pains of all new projects, but have provided some valuable results. The V2 was not really suited for this kind of work, being too heavy and too costly to operate, but trials are being continued with later and improved types of rockets. Today one is thinking of operational maximum heights of around 200 km. Tomorrow, possibly 500 km. will be considered as normal, but will it still be correct to consider experiments, carried out at these altitudes, as upper atmospheric research ?

SHELTER AND EXPOSURE IN WEST ANGLESEY

THE CLIMATOLOGICAL FREQUENCY DISTRIBUTION DIAGRAM AS AN AID TO LOCAL FORECASTING. PART II.*

By Frank A. Barnes, B.Sc.

RAIN

Figures 3 A–D illustrate the variation of rainfall amounts with wind speed and direction at Holyhead over a period of seven years. The modes, or most frequent values, of the wind speeds and directions were estimated for periods of appreciable rainfall. Occasions with very light or variable surface winds were not used. The corresponding rainfall amounts were grouped according to Beaufort scale divisions (a 16-point scale being used for direction), summed, and adjusted to represent amounts per m.p.h. within each Beaufort division. These figures were then entered on the respective diagram at the mid-points of the Beaufort divisions and the graphs completed as shown.

The major conclusions are simple to grasp. Previous ideas about the wind must, however, be borne in mind before the sheltering inference is carried too far. Rain from the direction of the Welsh Mountains may be associated either with light variable winds and not represented in the diagrams, or with winds diverted at the surface to another direction. The impression left by the figures is nevertheless striking. Obviously a much more useful correlation for practical use would be between rainfall amounts and the isobaric gradient wind over the NW. Wales area.

It is interesting to note that at all seasons the maximum of rainfall with SW. winds is associated with higher wind speeds than the maximum with southerly winds. The maximum associated with easterly winds admits of several explanations. It is probably partly due to some easterly diversion of winds by the hills, and the suppression of winds from adjacent directions south of east. Slowly-moving fronts crossing the area towards the continent are very prone to be held up by the Welsh Mountains for a time, and to remain in a quasi-stationary condition SW. to NE. across Anglesey. The better-marked examples of this synoptic condition are frequently quoted in meteorological literature. The July 1946 issue of *Weather* shows an example in Figure 1 on page 67. On many occasions, however, the situation arises temporarily. Small wave-depressions are then very likely to move quickly NE. along the front across the area with associated rain areas. Wind directions are variable owing to the proximity of the centres. During the rain ahead of the wave centres, however, especially if the waves are very small, winds are likely to be predominantly easterly at Holyhead.

Rain after a fair period, associated with the approach of a warm front from SW. or W., is frequently accompanied by a very marked backing of surface winds as far as SE. to E. in South and Central England. The backing is much reduced in Anglesey, due to the Welsh Mountains, and usually does not proceed there beyond about the south.

* Part I of this article appeared in *Weather* of April 1949.

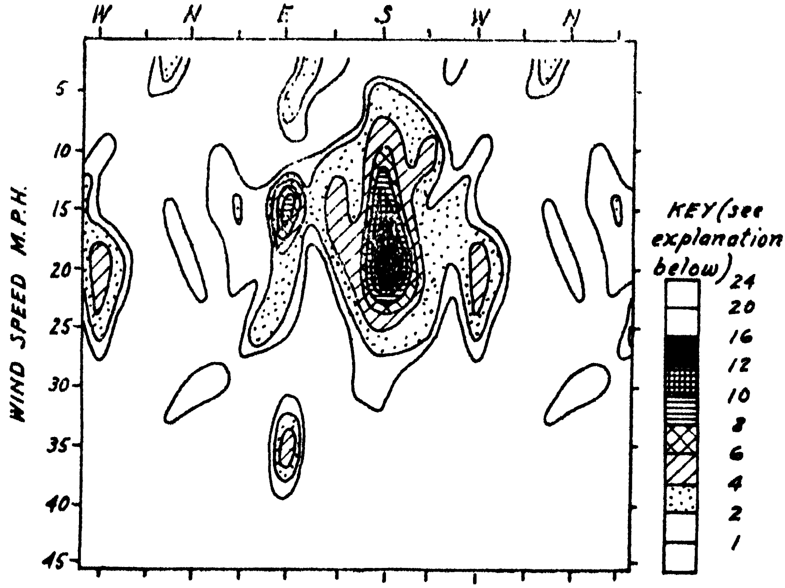


Fig. 3 A. Spring

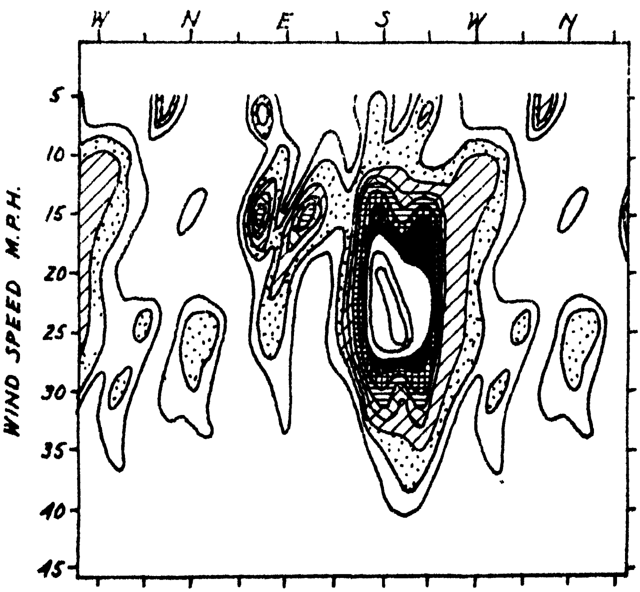


Fig. 3 B. Autumn

Variation of rainfall at Holyhead with wind speed and direction (1927–1933).
The figures from which the isopleths were drawn were obtained as follows:

1. Rainfalls for each wind direction and mode force, Beaufort scale, were summed.
2. These were then divided by the appropriate speed range of the Beaufort number.
3. The results were entered in diagrams divided up according to Beaufort numbers.

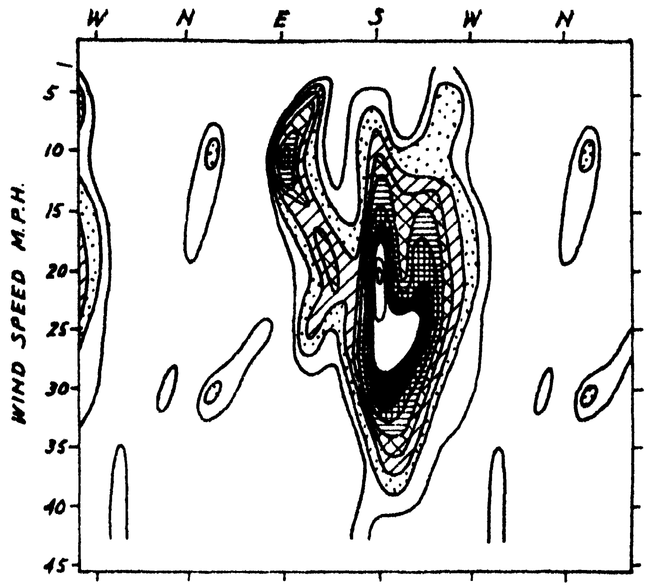


Fig. 3c. Winter

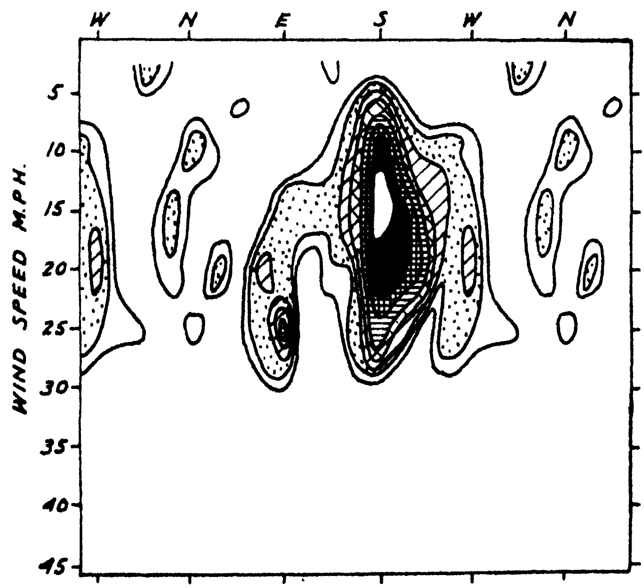


Fig. 3D. Summer

Variation of rainfall at Holyhead with wind speed and direction (1927–1933).

Various minor maxima in the figures are rather difficult to interpret because of the variety of causes they may represent. More detailed correlations (using the same method as above), relating rainfall and wind under synoptic conditions of various types, would be necessary to show how these maxima

and minima could be related to shelter and exposure effects.

The bulk of Anglesey's rainfall is frontal or cyclonic, air-mass showers accounting for a much smaller total amount. So the very real sheltering

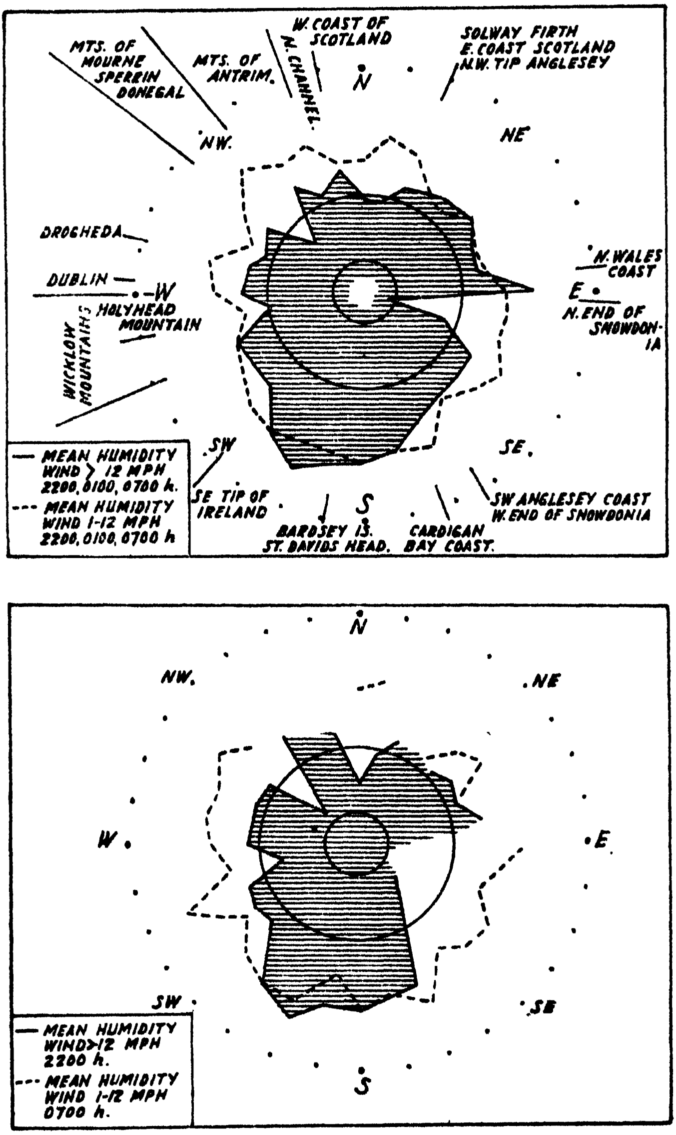


Fig. 4. Variation of humidity with wind at Holyhead, 1936

Compass-point circle represents 100%, inner concentric circles represent 80% and 70% respectively. Lower diagram shows effects of insolation and radiation.

effect of Scotland in "drying out" the showery northerly streams of air which cross it is not well shown. This is also partly due to the cancelling effect of variations in the curvature of the air-stream trajectories on different occasions.

Thus, according to isobaric configuration, a northerly stream at Valley may have crossed N. Ireland, or Scotland, or have passed through the North Channel.

HUMIDITY

Relative humidity is notably sensitive to shelter effects. Figure 4 refers to one year, 1936, at Holyhead. This year was average for sunshine and temperature and had slightly more than normal rainfall. Humidities were averaged for each direction on a 16-point scale. Stronger and weaker winds were distinguished, reflecting dominant control by distant and more local features respectively. These diagrams reveal the control of the geographical setting over humidity, even though the observations used are too few in number to give truly representative results, especially from S. to E. directions.

The maxima with SW'S. to S. winds are due to the combined effects of the southerly originating air passing into cooler latitudes and the absence of shelter. For straight isobars the directions SW'S. to S'W. give a full sea track between Ireland and Great Britain. The Lleyn Peninsula and Pembroke provide only partial shelter from southerly winds, and this is partly nullified by evaporation during the subsequent water passage. Also S'W. to S. winds are to some extent backed by the effect of the mountains (as shown above), and are most frequently cyclonically curved in trajectory; hence the high humidities as far round as S. Winds crossing Ireland show decreased humidity due to the increased frequency of air-streams of polar origin, and superimposed on this the drying effect of the land track, in particular from the directions of the Wicklow Mountains and the hill masses of N. Ireland. The effect of Scotland can also be seen. With S. to SE. winds average humidity increases as the effective distance from the Welsh Mountains increases, and as the air's origin, on the average, becomes increasingly more oceanic.

In the wind-humidity rose for 22.00 hours the " drying " due to insolation over the land masses during the daytime is noticeable. This effect is, of course, of a different order from that of true shelter, the dynamic effect of air passing over hills. It is largely illusory and not a conservative effect, being largely due to the increase of air temperature without appreciable reduction of specific humidity. Indeed, the drying effect of a mountain passage by the *Föhn* process is frequently exaggerated by the fact that the resulting dispersal of cloud on the lee side permits increased insolation at the surface, with a consequent rise of temperature.

CLOUD

Observations of cloud height and amount are not surface measurements. The intimacy of their relationship with surface conditions varies according to the stratification of temperature and moistness. Cloud at high levels is less affected by orography than is low cloud. Thus frontal cloud approaching from SE. may usually have its base as high as 5,000 ft. over Anglesey, and fail to develop scud beneath it, when the Welsh Hills are blanketed. Low stratus, or haar cloud, which may spread across from the North Sea into E. Wales night after night under certain conditions, never reaches Anglesey at all, as

its top is usually lower than 3,000 ft. On the other hand, a thick layer of strato-cumulus, "solid" between 1,500 and 5,000 ft. over England, may reach Anglesey, but it is in the form of patchy, thin cloud at about 4,000 to 5,000 ft. Scotland shows its influence under certain conditions. Thus an unstable, vigorous northerly stream of air which is giving much cumulus cloud in N. Scotland is often, especially in spring and autumn, relatively free of cloud when it reaches Anglesey, though it will give a constant cap of cumulus over Snowdonia.

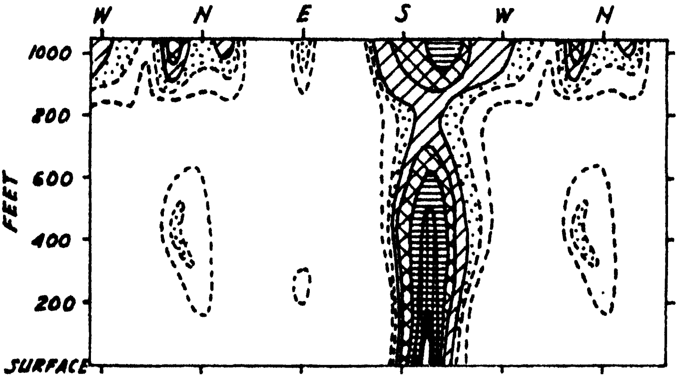


Fig 5 A. Stratus ceiling — cloud amounts greater than 4/10.

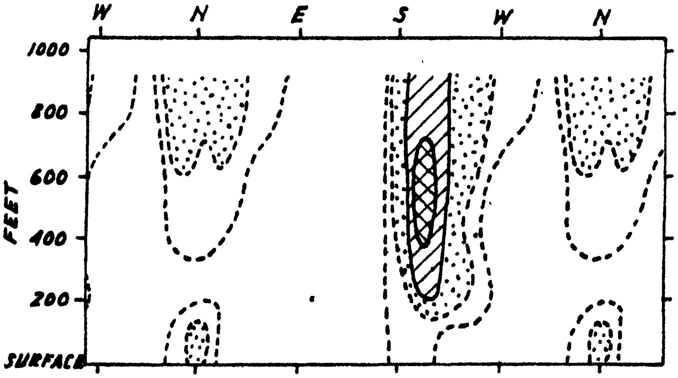


Fig 5 B. Stratus fragments — cloud amounts less than 5/10.
Frequency isopleths indicating number of occasions when the cloud base at Valley was in each 100-ft. interval, for each wind direction on a 16-point scale. Broken lines represent 1 and 2 occasions, stippling from 2-5, hatching from 5-10, and so on at intervals of 5. The black area is for 25-30 occasions and the white area within it is over 30. (Hourly observations in August 1942-1945, in which cloud heights were recorded by code figures; frequencies therefore adjusted to make them comparable over the height range before drawing isopleths.)

By contrast, minor cold fronts moving slowly from NW. often give thick drizzle, and very low cloud and poor visibility in Anglesey, especially when they arrive in the afternoon. This is so even though cloud and precipitation conditions were innocuous in NE. Ireland, and even in the Isle of Man. The sheltering effect of Ireland in such cases has been nullified in the lower layers by the subsequent passage over the Irish Sea. In fact it is usually found that fronts moving in from the west give quite similar weather conditions on the west

coast of Ireland and in W. Anglesey. On the other hand, air-mass conditions, e.g. " warm-sector conditions ", are frequently much modified when the air passes over Ireland. With winds between SW. and W., Anglesey rarely experiences persistent layers of very low cloud, even when the air mass is of tropical origin and giving fog on the W. Irish coast. But if the wind direction is SSW., and there is complete exposure, cloud is generally very low and unbroken.

The variations of stratus cloud heights can be demonstrated as in Figures 5 A and B. They show the very strong effects of shelter and exposure on stratus cloud cover. This is an example of the most useful type of correlation—it is confined to occasions with particular stability and other characteristics. Thus it has been found that, even with no direct information on sea temperature and only a rough knowledge of the properties of a particular oceanic air-stream, quite a reliable estimate may be made of stratus cloud height and approximate amount, using such empirical graphs in conjunction with the wind diagram and a forecast isobaric chart of average accuracy.

No " pure " climatological value is claimed for correlative diagrams such as those reproduced in this article. Neither can they replace sound knowledge of physical meteorology. But forecasting is a synthetic as well as an analytic operation. The value of such studies of a causative character is therefore real, and their use is simplified by the clarity of impression made possible by the use of the frequency-isopleth method. Further, these studies help in some measure to bridge the gap between the usually separate fields of weather and climate. This is particularly desirable in view of the fact that weather is the stuff of which climate is exclusively made.

BRITISH WEATHER AND CONTINENTALITY

By L. C. W. Bonacina

Everyone familiar with the rudiments of physical geography and climatology knows that the westerly type of weather is fraught with oceanic influences, and the easterly type with continental. So different indeed are the effects of west and east wind (or for that matter north and south) with their characteristic skies that the same landscape looks different in its expression of beauty, and even sounds and smells different, according as the sea or land factors attain full predominance. But Britain is a large island (sixth in size, as islands go, in the world) and this fact introduces a number of secondary reverse effects of continentality which, though usually ignored in text-books, are vital to an understanding of our weather. Thus westerly winds from the Atlantic are slightly " continentalized " by the time they reach the east coast, and east winds are partly " decontinentalized " in crossing the North Sea and sometimes, by a kind of third-order effect, become "recontinentalized" in crossing the country towards the west coast. I remember once, whilst staying on the coast

of Lincolnshire, being astonished to hear that in winter SW. winds brought more severe weather than NE. winds. The statement is not of course categorically correct, but it contains an element of truth which I quickly perceived. When the Midlands are under snow and a very cold night ensues, the local winds are liable to set out from the land seaward, and when this happens on the Lincolnshire coast a local SW. wind will bring a much lower temperature than a NE. wind coming over the North Sea, provided that sea remains unfrozen. In February 1947 the North Sea was on the verge of freezing up, causing the east wind to bring extremely low maximum temperatures to this country. When the land is covered with snow it is quite possible for a NE. wind to leave the south coast of Devon with a lower base-temperature than that with which it arrived on the coast of Yorkshire.

In warm, sunny, summer weather with east winds, the western side of England is often hotter than the eastern side; and conversely, in a cool westerly type of summer weather, when the west and south coasts may be getting invigorating sea winds, sultry land winds may be blowing on the east coast without any reverse afternoon sea-breeze. During such spells in July and August, east coast weather will not act up to its traditional reputation for being so very "bracing". A very interesting fact about wind on the east coast is that west winds from the Atlantic, as everywhere else in Britain, are the *prevailing* winds, but east winds from the North Sea are the *dominant* winds, causing trees in exposed situations to lean towards the west.

The conditions which occasion extreme winter cold in England are characteristically rather different from those which do so in Scotland. In the south they occur when a black frost from the Continent is wafted across the short sea passage in a stinging east or south-east wind. Then everything freezes up, snow soon falls and spreads, intensifying the cold. Such weather is much colder in the south than in the north, and readily spreads westwards to the Channel Islands and Cornwall, and even over to Southern Ireland. An outstanding example was the intense and prolonged frost from November to January 1890–91. Scotland by its more insular position is less subject to such continental frosts, but when a stream of intensely cold Arctic air pours southwards and an anticyclone subsequently settles down over the snow-filled Highland valleys, a severity of cold is developed which the south of the island, with its longer days and higher sun, seems unable to emulate. One recalls the astonishing maximum, of 10° F. in mid-November 1919 at Braemar in Deeside, and the week in mid-February 1895 when at Balmoral, in the same river valley, for several days the maxima were of the order of +15° F. and the minima of the order of −15° F. I have just remarked that the SE. of England is peculiarly liable to continental frosts because of the short sea passage; yet how effective the Channel is as an insulator is shown by the complete absence from the London records of any month remotely resembling the Paris anomaly of December 1879—by far the most rigorous month of any name ever recorded in the French capital, with a mean monthly temperature of 18° F., i.e. as much as 20° F. below the normal of 38° F. London's coldest December, 1890, was only 10° F. below the normal, and even then Paris was 14° F. subnormal.

I regard these questions of continentality and oceanity as essential to the full understanding of weather changes and anomalies. Some years ago (*Geographical Journal*, Vol. 64, 1924, p. 50) circumstances compelled me to do some pretty hard thinking on this subject and I came to the following inescapable conclusion which has remained the basis of my thinking ever since—if the surface of the globe were absolutely uniform, i.e. either all water without warm and cold currents or floating ice, or else all land of the same material without vertical relief, then air currents changing latitude would so quickly adjust their temperatures that a north wind would be little colder than a south wind, and contrariwise in the southern hemisphere. It is really due to the irregular distribution of land and sea, mountains, currents, ice, etc., that we have come to associate winds from various directions with pronounced thermal characteristics. In England we experience our most severe heat waves when, with brilliant sunshine, a south wind of long fetch, perhaps with a trajectory extending back into the Sahara, reaches us from heated France. But if the area of France were occupied by cool water, and if the sea between Scotland and Iceland were replaced by a broad land bridge of low relief which could be heated up, the thermal difference between north and south winds in summer would be largely neutralized. In winter irregular SW. winds could not conserve enough heat to bring temperatures upwards of 50° F. so far north as the British Isles if they did not follow the warm water of the Gulf Drift. We call NW. and N. winds cold by comparison, but here again we should soon know the difference if the hypothetical land bridge were to replace the warm water northwards of Scotland.

There is just one other effect of continentality which I should like to mention. We are accustomed to think of a continental climate as having hotter summers and colder winters than an oceanic climate in the same latitude, and this is, of course, the primary relationship as reflected in the range of mean temperature between January and July. But, on occasion, continentality can also tell in the direction of summer cold and winter warmth, because the sea always serves as a regulator against extremes. The inter-diurnal variability of temperature or change from day to day is greater on the Continent than it is in the British Isles. The smaller fluctuations have about the same frequency, but the bigger fluctuations are more common on the Continent (Hann's *Handbuch der Klimatologie*). In the eastern United States, where in winter air from off the Gulf stream may be in close proximity to Arctic air from Canada, changes of an order of magnitude unheard of in Western Europe commonly occur. How would Londoners react if on a January day the maximum temperature leaped up to 70° F., to be followed in 48 hours or so by a minimum below 0° ? Yet this order of change is by no means very uncommon in New York. I think we should recognize that in many respects our British climate is remarkably even and constant inasmuch as the sea effectively damps down the changes of temperature associated with the changing weather types. The reputation of the British Isles for especially variable weather is chiefly due to the unstable pressure situation which results in rapid sequences, or unexpected turns of wind, sky and weather.

ROYAL METEOROLOGICAL SOCIETY NEWS

THE GENERAL CIRCULATION OF THE ATMOSPHERE

The Society's lecture room was well filled on May 18, when the general atmospheric circulation was discussed ; Mr. E. Gold was in the chair. Dr. E. T. Eady opened by reviewing the problems of explaining the zonal flow shown in climatological maps and the transfer of heat and momentum across the lines of latitude. His main point was that the atmosphere was dynamically unstable ; when a given system broke down, waves of many different lengths could be formed, but one wave always tended to develop faster than the others—depending on the boundary conditions—and therefore dominated. Many who could not keep pace with the rapid delivery will look forward to studying Dr. Eady's thesis at leisure when it is published in the near future in *Tellus*.

Dr. A. G. Forsdyke summarized the paper " Heat transport and zonal stress between the latitudes " by C H. B. Priestley, which has already appeared in the *Quarterly Journal*. He emphasized the tentative nature of Priestley's conclusions and Professor D. Brunt subsequently remarked that the method might be applied on a larger scale by some French meteorologists.

The third opening speaker, Dr. R. C. Sutcliffe, claimed that the general circulation was a problem for synoptic meteorologists It had been shown that the friction at the earth's surface was sufficient to damp down the circulation in a few days, and that in some latitudes the earth would cool by 1° C. per day were it not for advection. The atmosphere must therefore strike a balance every few days Instead of putting all the available ingredients in the statistical sausage machine and hoping for the best, Dr. Sutcliffe thought that a better understanding of the physical processes would result from an examination of typical situations where the atmosphere had solved its own differential equations and had maintained steady conditions for several successive days. Climatological maps did not show a true solution of the equations.

Contributors to the ensuing discussion included Professor Sheppard, who suggested that the stratosphere ought to receive more attention. He thought that it was a mistake to regard the troposphere and the stratosphere as two watertight compartments, but Mr A W. Brewer pointed out that the world above the tropopause was very different from the wetter world we knew so well at the surface He thought that the extreme dryness of the lower stratosphere observed above England was direct evidence in favour of a simple general circulation, including a flow of air from the equator towards the poles at these heights, in spite of the dynamical difficulties placed in the way by Dr Eady.

O M.A.

FORTHCOMING MEETINGS

On Wednesday, June 15, 1949, at 5 0 p m., in the Society's rooms, the following papers will be read by Professor Brunt, F R.S., and Dr J. S. Farquharson respectively, in the absence of the authors overseas :

(a) " The dissipation of scattered and broken cloud " by E. W. Hewson, M.A , Ph D., F.R.S C. (see *Q J.*, Vol. 74, p. 243), and :

(b) "Synoptic applications of the frontal contour chart : the motion of selected lows, 5-7 November, 1946 ", by A. M. Crocker, M.A. (see *Q J.*, Vol. 75, p. 57).

On Wednesday July 13, 1949, the Summer Meeting of the Society will take place at the Royal Aircraft Establishment, Farnborough, Hants. Details of this meeting have been promulgated separately to Members of the Society in the June Meeting Notice.

THE WEATHER OF MAY 1949

SUNNY ; DRY AT FIRST, RAIN LATER.

Apart from some high sunshine totals, especially in the West, there was nothing particularly unusual about the weather of May. The dry spell continued almost unbroken in the South and East until 15th, but by the end of the month farmers and gardeners were probably satisfied though many Water Board Authorities will continue to have cause for concern unless the rainfall for the next few months is at least normal.

An anticyclone centred over the British Isles at the beginning of the month maintained fair or fine and dry weather for several days. From the 5th to 8th there was a short spell of unsettled, north-westerly type of weather, but on 10th another anticyclone covered the country. Northerly winds bringing air from high latitudes, together with clear skies, were accompanied by low night temperatures : what is believed to be the most severe frost in May for many years caused damage to fruit in the South-East on the nights of 8th to 10th : screen temperatures of between 32° and 35° F. were common, while grass minima of 20° F. were reported from Lincolnshire, Kew and Doncaster.

By 14th pressure had fallen and hopes of rain were raised when thundery weather was forecast the next day. Falls were small, however, though heavy locally on 16th, 17th and 20th. On 23rd a small secondary moving eastward over the South Midlands was associated with rain that became heavier and more prolonged as it spread over South-East England ; at Kew the rainfall, 18mm., was the largest on any day since August 8. From then until the end of the month an unsettled westerly to south-westerly type prevailed.

From overseas we hear more of the evils than the blessings of weather At the beginning of the month, while Britain was enjoying anti-cyclonic weather, pressure was low and weather was unsettled over the Mediterranean and North Africa. At the end of April and beginning of May the Marrakesh region of Morocco suffered from the worst rain storms on record , several persons were killed, bridges and houses swept away and roads were flooded. From Italy, where by May 4 the River Po had risen 13 ft. to its highest level for 20 years, more damage due to flooding was reported. In Canada, continued dry weather was giving cause for speculation over the wheat crop this year, while the River Amazon was, on 23rd, in flood to such an extent that Maceio, the Capital of Alagoas State, was cut off and 100 people had been drowned. From New York was reported on 6th the highest temperature on record (92° F) for this date, and from elsewhere serious damage caused by tornadoes in Texas and Missouri

	TEMPERATURE (°F.)				RAIN (mm.)*			SUNSHINE (hr.)		
	Long period Average Max.	Long period Average Min.	This month Extreme Max.	This month Extreme Min.	Month	Diff. from Av.	Last 12 months	Month	Diff. from Av.	Last 12 months
Kew Obsy.	62·5	46·6	69	35	60	+15	488	216	+18	1532
Gorleston	56·8	45·8	63	35	41	— 3	486	175	—48	1594
Birmingham	58·7	44·1	70	36	56	+ 2	765	213	+42	1333
Falmouth	58·5	47·5	†62	†39	81	+25	860	288	+81	1676
Valentia	56·9	46·7	67	38	91	+ 6	1338	199	+15	1179
Aldergrove	58·5	42·9	70	33	47	—16	851	194	+ 6	1215
Holyhead	54·8	46·5	69	34	42	— 8	761	256	+54	1483
Tynemouth	53·9	44·1	72	36	18	—33	511			
Renfrew	57·6	41·6	70	33	60	0	1274	219	+57	1247
Aberdeen	54·0	40·6	68	34	48	—19	775	202	+22	1436
Stornoway	52·8	42·2	66	33	63	— 7	1309	147	—32	1129

* 25 mm. = 1 inch (approx.) † The Lizard C.R.B.

PILOT-BALLOON THEODOLITE DEVELOPMENT

By J. A. Armstrong

Part II. Techniques in Instrument Making

Part I of this article reviewed the development of the balloon theodolite without referring to any of the interesting techniques employed by the instrument maker in the production of the high-precision instruments available today. In the second part of the article it is proposed to give the reader a little information on this subject.

The demands of the scientist, the surveyor, the meteorologist, the engineer, chemist and manufacturer for more accurate instruments in larger quantities have necessitated considerable changes in the scientific instrument industry. From the production of relatively few products by craftsmen who made the entire instrument from start to finish, instrument making has progressed to a highly organized industry in which hundreds or thousands of component parts are produced by specialized machines so that they can be assembled with a high degree of interchangeability. Modern methods of production control and planning have been adopted, and by the use of jigs and gauges an accuracy of one-thousandth of an inch, or less, is achieved in the important dimensions of piece parts.

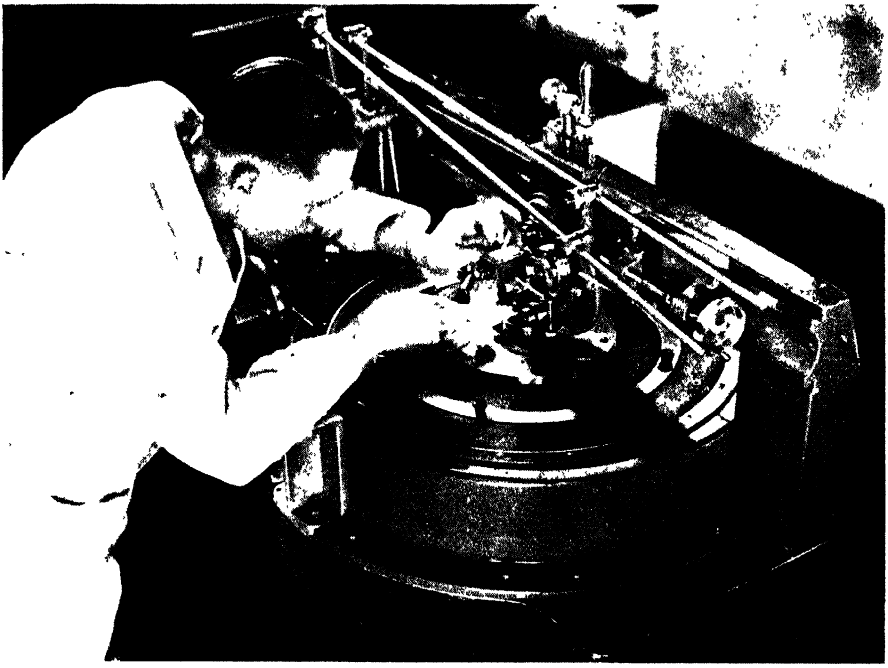
Circular and linear scales, which form a fundamental part of so many instruments, are now divided on precision dividing machines which, in accuracy and speed of operation have advanced a long way from Ramsden's circular dividing engine, on which the circles of his early theodolites were engraved. The use of glass for circles instead of metal has altered some instruments almost beyond recognition, for it is possible to engrave on glass lines no thicker than a few ten-thousandths of an inch thick. These, when illuminated and viewed with an optical magnifying system, provide a clear and direct reading to one second of arc or less, a development which has enabled the designers to reduce the size of the circles of a primary triangulation theodolite, for example, from 18 inches in diameter to 6 inches, and those of instruments for less accurate work to as little as 3 inches.

The Watts dividing machine shown in Plate III will divide automatically any required angular spacing without attention from an operator beyond setting up and switching on. From master scales made on such a machine, photographic copies can be made for many classes of instruments.

OPTICAL GLASS

One of the greatest bottlenecks in the production of optical instruments for the 1914-18 war was caused by the lack of optical glass, a field in which the Germans were at that time supreme, but the incentive given then to the British manufacturers has resulted today in a range of products which is unexcelled; British lenses now bear comparison with any in the world.

The primary raw material of glass is sand, and the quality of the product depends on the purity of the sand. The discovery at the outbreak of the recent war of a remarkably pure sand in Scotland, sand equal to that used by the Schott



Machine for engraving glass scales

Sealing the ends of spirit levels

Machining the graticules

Taking observations with a pilot balloon theodolite

PLATE IV

Glass Works in Germany, finally removed the handicap under which we had laboured for so long.

Lenses are produced from moulded blanks of glass by first rough-grinding to the required curve on a steel tool with carborundum abrasive, or by diamond grinding on special machines. They are then set in pitch on a large tool (as shown in Plate III) for smoothing and polishing. The curvature of the lens is checked with a test plate, which is a block of glass accurately ground and polished to the complementary curve. If the curve of the lens and the curve of the test plate do not agree, interference colours appear, produced by light in the thin air gap rather similar to the colours produced by an oil film on a wet road. By means of these interference colours the correctness of the lens curvature may be measured to a few millionths of an inch. After both sides of the lens are polished, it is edged so that the diameter is true to the curve.

The objective lens on the pilot balloon theodolite, the aperture of which has been increased to improve the sighting ability in poor light, consists of two lenses cemented together. The telescope of a modern theodolite may contain as many as nine lenses, all accurately made to the optical designer's computations.

Whilst coarse spirit levels, such as are used to level a billiard table, are made by bending glass tube into a curve (see Plate IV), accurate spirit levels required on instruments are produced by internally grinding the tube on a special machine in such a way that its section is always round but larger in diameter in the centre than at the ends. It is then sealed at one end and drawn to a pip at the other through which the liquid, usually ether, toluene or alcohol, enters under vacuum; afterwards the tube is sealed in the blow flame. Spirit levels can be made which will record tilts of as little as a few seconds of arc.

CONCLUSION

Naturally, in an article of this length is is impossible to do more than touch lightly upon the subject and to describe only one or two processes. Some idea of the complexity of the day-to-day tasks may be obtained if it is realized that a modern optical theodolite may incorporate as many as 450 parts. From the designer to the toolmaker, the machinist and the assembler, a team of craftsmen, each one an expert in the particular job for which he is responsible, work to create a finished instrument which will conform to all the needs of its user.

The position of the scientific instrument maker is of paramount importance in Great Britain today. Upon his instruments depend the progress of scientific observation, the control of most manufacturing processes—whether in foodstuffs, textiles, or production, chemical, or electrical engineering—and all large and small scale construction work.

LETTERS TO THE EDITORS

The Border Floods — August 12, 1948

It would have been rather wonderful if this concentration of prolonged rainfall could have been forecast for the area where it actually occurred ; but a forecast would not have stopped the disaster which happened to the railway along the course of the river Eye.

I travelled along that length of railway at about 4 miles per hour in early November, when it had just been re-opened for traffic. High railway banks cross the river several times, with only calverts to pass the river discharge. At the time of the disaster, the river water was far more than the calverts could take and it piled up into a large reservoir behind the railway bank until the velocity of flow carried away the calverts. There were 7 miles of river length and 11 sq. miles of catchment above the railway crossing.

Down such a stream, without lake storage, a flood peak travels at about 4 m.p.h. and the peak flood would have reached the railway bank in 2 hours ; with the ground already saturated, the rate of run-off from 11 sq. miles would reach the average intensity of the rainfall during those two hours.

Dr. Glasspoole gives the actual rate of rainfall at 1.9 inches in 2 hours. My table of extreme rainfall for flood estimates gives about 1½ inches in 2 hours from 10 sq. miles.

One inch per hour from 1 sq. mile yields an average flow of 650 cu. ft. per sec.

At ¾ inch per hour from 11 sq. miles the flow would be 5,300 cu. ft. per sec. The river would have to be crossed by a bridge of at least 50 ft. span. Dr. Glasspoole's rainfall figure of 1.9 inches in 2 hours would give a flow of 6,700 cu. ft. per sec.

There does not appear to have been any enquiry into this costly disaster ; but clearly some proper organization of records would provide explanatory facts. The Tweed dams a large area of 1,900 sq. miles. Surely State Survey could establish and maintain a few monthly or weekly recording rain and water level gauges. One good surveyor, with a car, could deal with such gauges and their " hour to hour " records.

London, W.8 — W. N. McClean

A Meteorological Illusion !

A famous journalist once said : " If a dog bites a man, that isn't news, but, if a man bites a dog, that's news ! " Similarly, if an observer sights a tornado or whirlwind, that isn't news, but, should the observer see that pendent trunk of cloud ascend from earth to sky, and then form a cloud, that's news ! One afternoon in the Autumn of 1947, when in a valley in SE. Scotland, the writer was amazed to behold what appeared to be a tornado or whirlwind at no great distance. Astounding to relate, a tenuous snake-like trunk soared heavenwards, and suddenly commenced to form a very ominous-looking dark cloud, approximately a thousand feet in height at about a mile off. The cloud at once began to grow in dimension until it appeared to be about three-quarters of a mile long and a quarter in breadth. Suddenly, the trunk shortened, and disappeared into its cloud, which immediately approached at great speed, making a peculiar sound as it drew near.

Amazement gave place to interest, on finding that the illusion of a tornado or whirlwind in reverse, had been caused by—a huge flock of starlings ! During the quiet warm weather of the late summer anticyclone or col, which autumn had " borrowed ", the slopes of the valley were no doubt heated by the sunshine, and the temperature of the air in contact with the ground had risen, causing it to expand, and so the warm light air thus formed had flowed up the slopes of the valley as a gentle wind, since it was rising against gravity ; and the birds, perhaps in their eagerness to ascend and enjoy the pleasant sensation created, had soared in their thousands in follow-my-leader formation.

Melrose, Roxburghshire — G. Bain Ross, M.A.

Convection Cloud and Industry

Further to D. L. Champion's letter in *Weather* of November, whilst flying over Yeadon Aerodrome, near Leeds on November 18 at 15.00 G.M.T., I noted two or three small cumulus cloud tops, projecting 400ft. above the level of the thick haze that was covering the industrial area to the west, and which rose to 2,000ft.

Investigation proved that these clouds were formed above the power stations at Leeds, Bradford and Halifax in the same manner as that noted by Mr. Champion. No doubt the moisture vaporized into the air from the cooling towns was the cause of the increase in humidity, and the hot air from the chimneys the origin of the thermal.

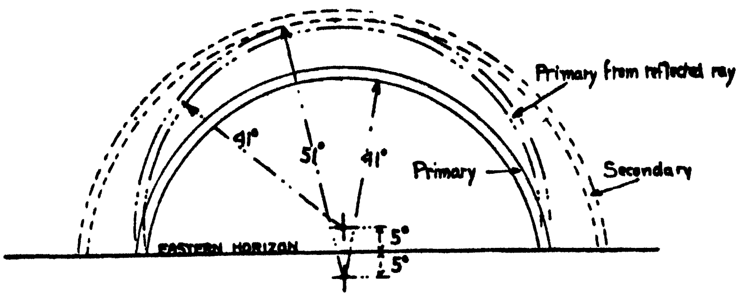
The weather at the time was anticyclonic with no wind and a cloudless sky.

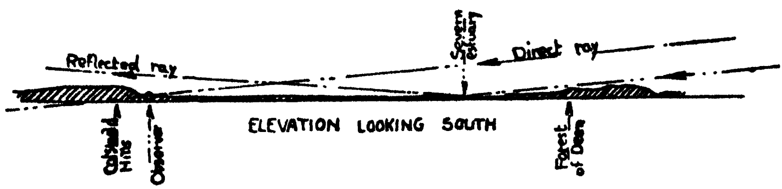
Shelf, nr. Halifax — H. Whitaker

A Displaced Primary Rainbow

On the evening of September 13, 1948, just after a well-marked line squall from the west, and with a bar of clear sky opening up on the western horizon, a brilliant rainbow appeared in the east. As the sun was then only about 5° above the western horizon, the greater part of a semi-circle could be seen. The bow consisted of the primary and a well-marked secondary with the colour sequence reversed as usual. What I had never seen before, however, was a third bow, a replica of the primary, but displaced upward, so that its top approached the secondary ; i.e., the centre of the arc was about 5° above the eastern horizon, while the primary centre was, of course, 5° below. The horizontal diameter of this third, eccentric bow was approximately the same, or slightly greater than the primary.

Now, six miles to the west is the mile-wide estuary of the River Severn. Many times, looking from the Cotswold escarpment, in the evening, have I seen the blinding reflected image of the lowering sun on the calm water of the tidal estuary. At such a glancing angle the water is almost 100% reflective. The reflected ray would strike upward at an angle of about 5°, which would produce the third and raised rainbow.





It seems to me that this phenomenon must have been seen many times before, in the vicinity of bodies of calm water. The upward displacement of the eccentric bow would be double the angle of the sun above the horizon. If the reflected image of the sun was diffused by a rough water surface, the third bow would be so scattered as to be invisible.

This displaced bow was commented upon by other local residents.

Dursley, Glos. PERCY B. ASHWORTH

St. Elmo's Fire near Glencoe

On the December 30 last year two of us observed a display of St. Elmo's Fire on the An-t-Sron ridge of Bidean nam Bian, above Glencoe, which we were descending at dusk after a day's climbing. At about 5.30 p.m., just before it was necessary to use lamps, I noticed that my companion had acquired a halo. His head was swathed in a greenish-white glow, which proved on inspection to be caused by numerous brush discharges emanating from the particles of ice on his balaclava helmet. The glow was easily visible in the dusk at a distance of about 15 feet. Our height at this time was just under 3,000 feet.

Further, greenish-white brush discharges appeared at the tips of our mitts and various projecting parts of our clothing. Presently the ice axes began to sizzle in the traditional manner, and the picks were seen to be emitting fine purple brushes, an inch or so in length. The sizzling and the brushes ceased when the two axes were approached within about a foot of each other. They also ceased when the axes where held out of the wind, in the lee of our bodies, and increased very considerably when the axes were raised overhead.

Incidentally, we discovered that we could spit green fire, like dragons.

These phenomena lasted for about 15 minutes. There was no suggestion of a thunderstorm at the time ; a few peals of thunder had been heard during the morning, but by

evening the sky was almost clear. However, a strong wind was blowing across the ridge, carrying swirling masses of ice particles about the size of small hail. Miniature local blizzards of this sort had blown intermittently most of the day. It seems probable, therefore, that the electrification was produced by impacts between ice particles, as described by Simpson in *Quart. J.R. Met. Soc.*, Jan. 1942.

Napier Shaw's *Manual of Meteorology*, Volume II quotes in the section on St. Elmo's Fire an extract by Buchan, in which it is stated that the weather about the time of such displays exhibits certain definite characteristics, so well-marked that it is recognized as " St. Elmo's weather ".

I should be interested to hear whether there was evidence of the characteristic conditions on this occasion.

E. Greenwich, S.E.10 J. E. Bowman

National Meteorological Service

The Editorial in your April number reminds me of a resolution which was passed by the Royal Meteorological Society on February 18, 1920. It runs as follows :—

" The Royal Meteorological Society observe that in the Air Estimates for 1919-20 published last December there appears a sum of £12,000 as a supplement to the grant in aid of the Meteorological Office. It would appear from this that it is intended that the finances of the Meteorological Office shall pass under the control of the Air Ministry.

" The Meteorological Office deals with a variety of problems of high scientific and practical importance, some of which have no bearing on the work of the Air Ministry, but are closely connected with the work of other Government Departments. While recognizing to the full the great benefits to the meteorology of the upper air likely to accrue from a close association with the service to which a knowledge of the upper air is so essential, and which possesses such facilities for its investigation, this Society cannot but feel misgiving that there may be a tendency for other branches of meteorology to receive less than their due attention if one Government Department has the sole control of the finances and management. The Society therefore are of opinion that the Meteorological Committee should continue to have full control of the expenditure."

It would be interesting to know what the opinion of members of the Society on such a resolution would be today. Some would argue that such vast sums as are now paid for the Meteorological Service would have been impossible had the Meteorological Office not been taken over by the Air Ministry. Those who argue so I would refer to Genesis Chapter 25, verses 29 to 34.

Petersfield, Hants. C. J. P. Cave

SIR NAPIER SHAW COMPETITION 1948

The judges consider the entries disappointing in number and quality and in the circumstances only the following awards are made :

SENIOR SECTION

1st	Prize	£10	Withheld
2nd	Prize	£5	F. W. M. Ruck : " Low Stratus on St. David's Head."

JUNIOR SECTION

1st	Prize	£5	R. M. Glaisher : " Wind and Sea at Lagg."
2nd	Prize	£3	Withheld
3rd	Prize	£2	Withheld

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This Radiosonde was developed by Salford Electrical Instruments Ltd., in conjunction with the Met. Office, and is being manufactured in large quantities. It comprises a radio transmitter which is modulated alternatively by an audio-frequency which depends upon the temperature pressure and humidity. The met. elements have been chosen for their stability and cyclicity, and its results are better than any similarly priced instrument in the world.
Where it is necessary to use a really accurate and reliable Radiosonde, capable of simple interpretation of results, the "Salford" Radiosonde cannot be improved upon. The instruments we offer are individually calibrated, ensuring that the potential accuracy is always attainable.
Production is on a large scale, and this Company is always in a position to give a quick delivery for export, in addition to those which are being supplied in large quantities to the Meteorological Office. We shall be pleased to supply full technical data on request.
Salford Electrical Instruments Ltd.
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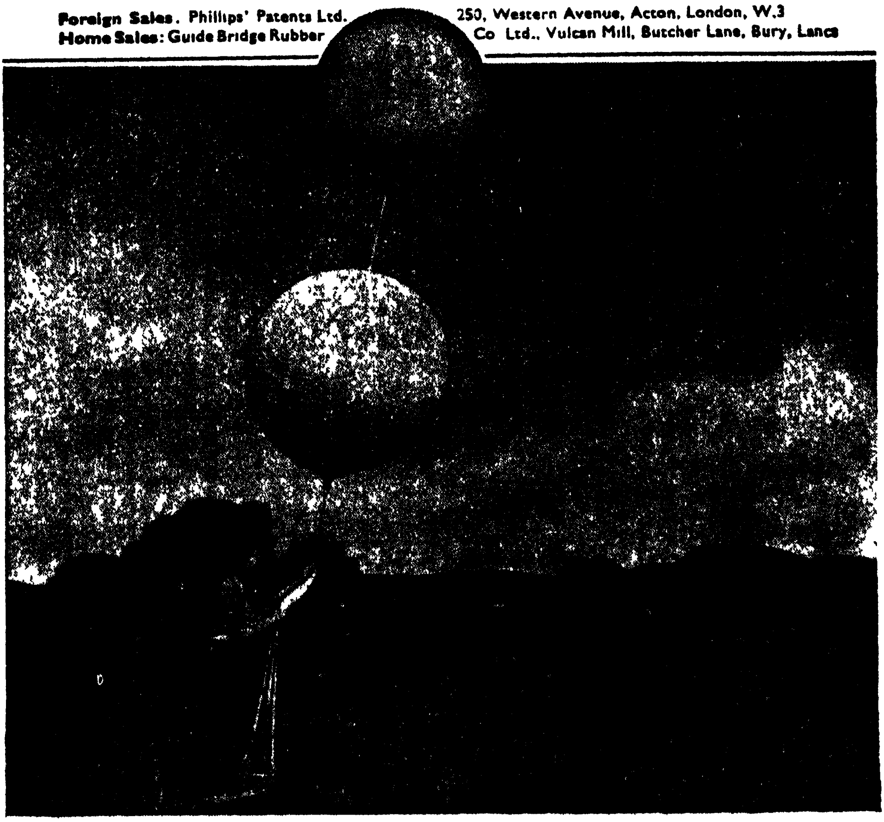

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JULY 1949

WEATHER

Vol. IV No. 7

CONTENTS

EDITORIAL

Snow and ice are relatively rare phenomena in the total history of the earth's surface ; today about a tenth of the surface is permanently covered, as we are still suffering from the effects of the Ice Age. The so-called Post-Glacial Period is merely one of amelioration in the climate since the end of the last ice advance of the Quaternary Ice Age, some 6,500 years ago.

Traceable evidence of life from fossil remains dates back about 600 million years, and man, including his primitive forbears, has only been here about a million. Geologists now reckon the total age of the earth to be at least 3,000 million, during which period there have been at least four ice ages. The Quaternary (or Pleistocene) is estimated to have lasted only about one million years as compared with some 50 millions for each of the others. The total duration of ice ages is, therefore, only slightly greater than 5% of the earth's existence.

These long-term, widely separated bursts of cold were interrupted by shorter-term oscillations of extreme cold and relative warmth (as today), during which time the polar ice caps seldom melted (see article on page 206 and review of C. E. P. Brooks's revised edition of *Climate Through the Ages*, page 212) ; when we consider the last few thousands of years we find even shorter term fluctuations and, in the limit, mere weather changes (see article, page 228).

Correspondingly rare are polar fronts and attendant depressions, for, during the great periods between glaciations, the earth's thermal gradients were smoothed and the land was mainly low lying with great areas of shallow seas and swamps. Shallow depressions and thunderstorms were then the order of the day.

But what of the future ? A few more oscillations, perhaps, before the ice once more disappears, and then aeons of time with no marked fronts nor refreshing winds—millions of years of hot-house weather. But Man, if he is still here, will not forget what ice looks like ; presumably he will have a plentiful supply of refrigerators to prevent the milk from turning sour !

FIFTY YEARS OF ENGLISH WEATHER

By R. B. M. Levick

It is noteworthy that certain types of weather, recognizable by their climatic features as well as the form of the isobars over and near the country, are inclined to persist for a considerable time—usually for a few days, and sometimes (especially the westerly type) for a few weeks.

Recently I have had the opportunity of examining the synoptic charts and weather reports of the past fifty years, and from these I have constructed a diagram covering the area of England and the period 1898-1947, which gives a complete picture of the occurrences of these types. It is, I believe, the general practice nowadays to describe weather in terms of types, although the number of types varies from very few to a great many, according to various systems of classification. I therefore decided to recognize six of them—the maximum number in which their characteristics appeared to me to be sufficiently distinct from one another—and called them the easterly, northerly-cyclonic, north-westerly, westerly, southerly and anticyclonic types, definitions of which are given below. I have experienced no difficulty in making a definite classification on all days except, possibly, four or five a year.

So far I have confined investigation to England, since it often happens that the weather in Scotland or Ireland is of a different type to that being experienced in England. For example, when a persistent anticyclone on the Continent extends over most of England, a depression usually exists on the Atlantic, and troughs of low pressure moving north or north-east along our western seaboard cause continual cloud and drizzle in Scotland and Ireland, with strong winds between south and south-west—a distinctly southerly type of weather in these areas, but anticyclonic in England. In the same way it often happens that when an anticyclone is centred over Scandinavia, England is far enough away from it to be influenced by depressions to the south or south-west which are accompanied by an unsettled (easterly) type of weather, while conditions over Scotland are anticyclonic.

In making these investigations I have been attempting to provide an answer to the problem : does the frequency of occurrence of the types vary in regular cycles, either over a number of years or from month to month ? The answer is, apparently, that no regular cycle is in operation apart from an annual one which, however, is well-marked. It would appear from an examination of the two 25-year periods 1898-1922 and 1923-1947 separately, that most of the pronounced maxima and minima covering short periods of ten days or so would in the long run cancel one another out—(though possibly not all of them : their positions in the two 25-year diagrams of the southerly type show a distinct correspondence which may not be altogether due to chance). The annual cycle, therefore, is probably a gradual one. In addition, it is interesting to note that the frequency of the southerly type seems to have been gradually decreasing throughout the fifty-year period, and the sudden increase of the easterly type to about double the average in 1939, 1940, 1941, 1946 and 1947 is striking.

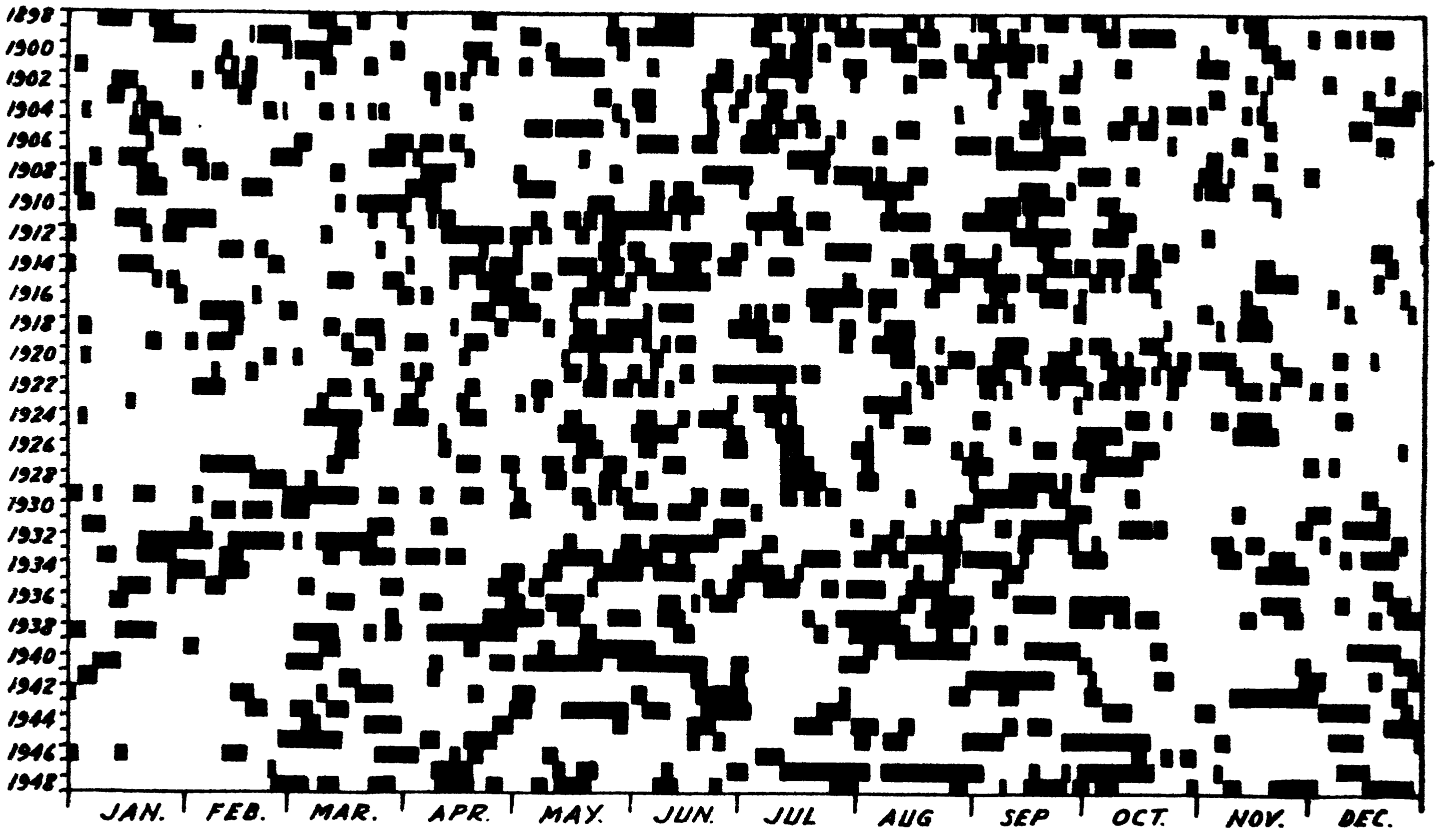


Fig. 1. General survey showing "anticyclonic" (black) and "unsettled" periods. All weather types giving appreciable precipitation are here classed as "unsettled".

The six weather types are defined below and the frequency of occurrence of these types for the period 1898-1947 is exhibited diagrammatically in Figures 1-3. In Figure 1, which gives a general picture of the weather during the 50 years, only two broad classifications have been employed, namely "anti-cyclonic" and "unsettled." Figure 2 shows the annual variation, and Figure 3 the monthly variation of the six weather types.

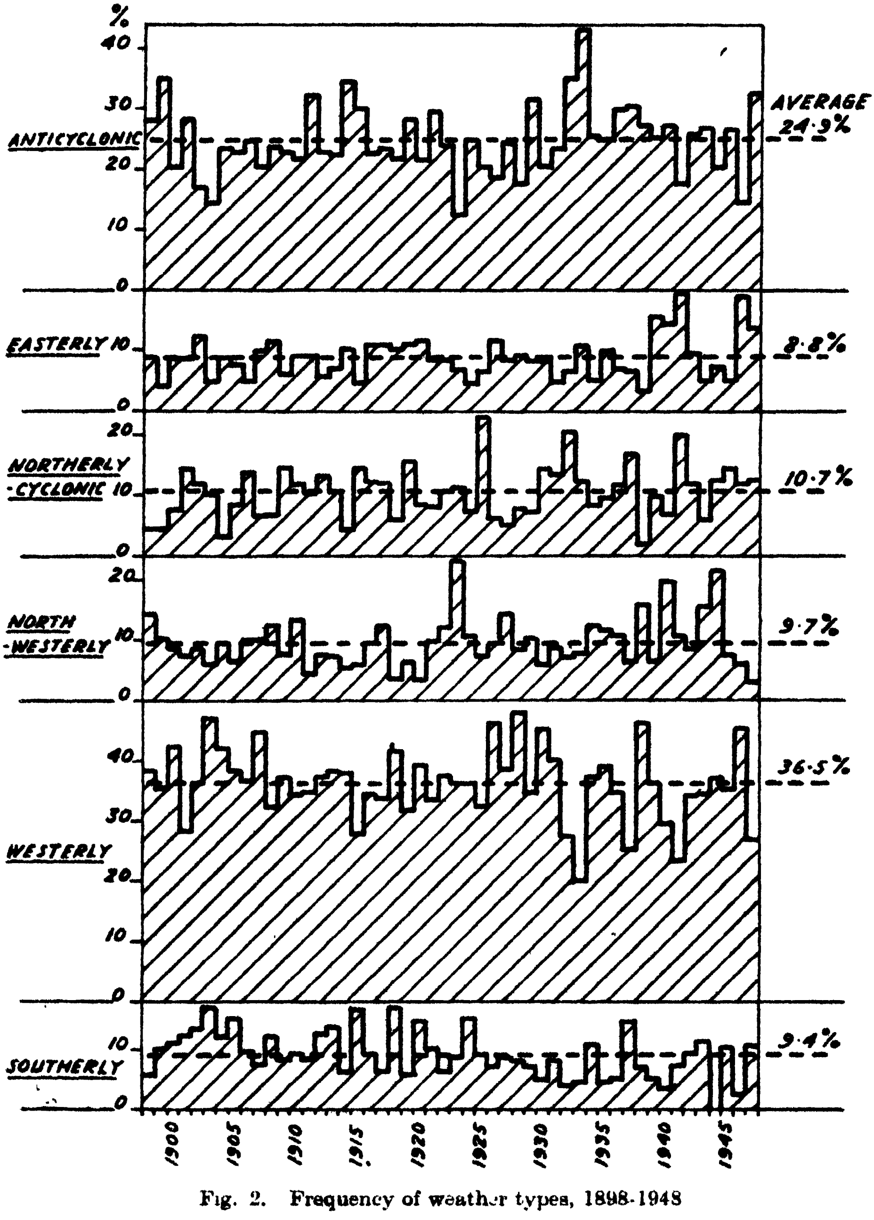


Fig. 2. Frequency of weather types, 1898-1948

1. *Anticyclonic type*. Associated with an anticyclone centred over or near Britain, or with a col between two anticyclones. Mainly dry with light winds. Warm in summer ; misty in autumn ; very cold in winter.

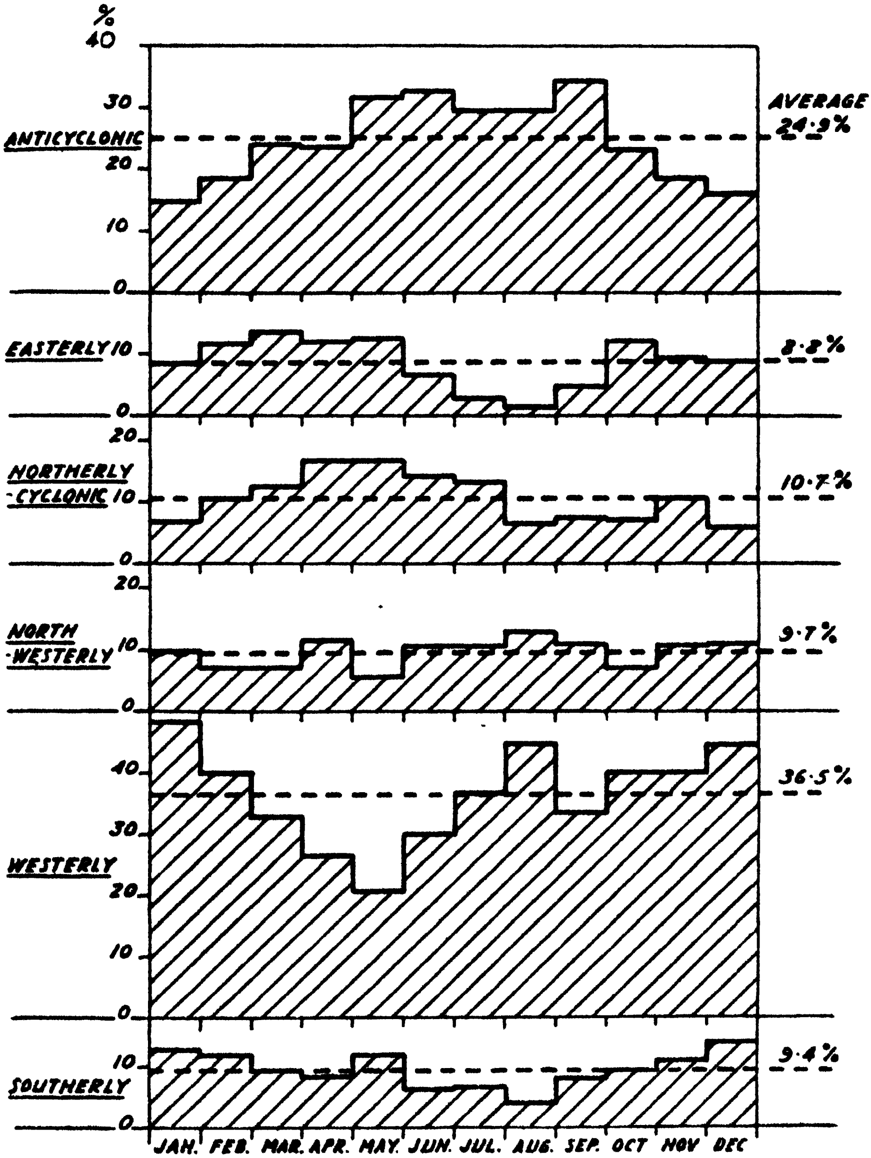


Fig. 3. Seasonal frequency of weather types

2. *Easterly type*. Associated with an anticyclone over Scandinavia or high pressure from Scandinavia to Iceland, and with a persistent low-pressure

area to the SW. or S. of Britain. Depressions, often intense in winter, frequently move SE. from mid-Atlantic to the Bay of Biscay. Intensely cold from December to March with frequent snow. Warm and thundery from June to August.

3. *Northerly cyclonic type.* Associated with an anticyclone to the west and north-west, producing a flow of polar air over the country. Depressions, often intense, move slowly southwards over Scotland and England or the Western European seaboard, or alternatively take the form of large stationary complex areas of low pressure while a belt of high pressure extends from the Greenland-Iceland area to the Azores. Cold and unsettled at all times of the year, with snow or sleet in winter.

4. *North-westerly type.* Occurs when the Azores anticyclone moves somewhat north and east, with its centre between the Azores and Britain. Similar to the westerly type with its unsettled weather and changeable temperature, but colder on the whole, since the air of the warm sectors comes from higher latitudes.

5. *Westerly type.* Associated with the absence of anticyclones of any permanence near Britain, when a sequence of troughs, depressions and ridges moves from west to east across the country. Unsettled, with winds shifting rapidly between south and north-west, and occasionally east for a short time. Cool in summer; mild in winter, with frequent gales.

6. *Southerly type.* Associated with an anticyclone over Central Europe which prevents Atlantic depressions from moving eastward and tends to make them circulate in mid-Atlantic. Warm and thundery in summer; very mild in winter with light to moderate rainfall and often strong winds from between south and south-west.

CONCLUSIONS

There would appear to be no well-marked cycle with a period extending over a number of years, but on the other hand there is a marked difference in the average frequency of the various types from month to month, with the result that the characteristic climate of a particular month is not always what one might expect. The occurrence of the various types during each month is summarized below.

January. Frequency of southerly and westerly types well above average; that of anticyclonic type well below. Exceptionally unsettled, therefore, and generally mild for the time of year.

February Increase in frequency of the easterly and northerly types, with a corresponding decrease in the westerly and southerly type. Cold spells accordingly more likely.

March Easterly type maximum; northerly above average. Cold spells therefore even more likely than in February.

April Northerly and easterly types still well above average—also the north-westerly. Generally cool, therefore, for the time of the year, and unsettled.

May Marked increase in frequency of the anticyclonic type, at the expense of the westerly and north-westerly types. (The westerly type has now reached a distinct minimum). The frequencies of the easterly and northerly types remain high, and there is a marked (temporary) increase in the southerly type. During this month, therefore, the weather tends to go from one extreme to the other—exceptionally warm summer-like days (but often thundery) alternating with reversions to a wintry type of weather.

June Increase in frequency of the westerly and north-westerly types mainly at the expense of the southerly. Northerly type still above average. Unseasonably cool unsettled spells therefore tend to become more frequent, though warm settled anticyclonic weather is as frequent as in May.

July Marked decrease in frequency of the easterly type, which is now very rare indeed; the southerly type frequency is also below average, while that of the westerly type is increasing rapidly. Somewhat more cool and unsettled for the time of year than June, therefore, but with less likelihood of thunder.

August Easterly type minimum: northerly as well as southerly type well below average, while frequencies of north-westerly and westerly types are high. Mainly unsettled, therefore, and cool for the time of year, though warm settled anticyclonic periods are not infrequent.

September Anticyclonic type maximum. There is also some increase in frequency of the southerly type at the expense of the westerly. For the time of the year, therefore, September tends to be somewhat warmer and more settled than August.

October Decrease in frequency of the anticyclonic type, while that of the westerly and easterly types is increasing. Becoming more unsettled.

November Frequency of the anticyclonic type continues to decrease, while that of the unsettled types increases.

December The frequency of the southerly type, which has been increasing gradually since August, has now reached a maximum: while those of the northerly and also the anticyclonic types are at a minimum; that of the easterly type is only average. Apart from very occasional cold spells, therefore, the month is unsettled and mild for the time of the year.

We hope to publish similar articles by R. B. M. Levick in due course on the weather of Scotland, Ireland and elsewhere.—EDITORS.

CLIMATE THROUGH THE AGES *

395 pages, 39 figures, 31 tables
Ernest Benn, Ltd., 1949, 21*s*. 0*d*.

By C. E. P. Brooks
(*revised edition*)

Concise long-term forecasting is a thing of the future! As, to some extent, the future of human experience can be planned and foreseen from the historical past, so should that of weather and climate, in the long-term sense, be predicted by the evidence provided from geological records.

This revised edition of Dr. Brooks's book puts comprehensively and into an astonishingly short space most of what is at present known of the geological record of climate, together with the latest theories concerning the evidence for historic climatic changes. Included, too, is the substance of most, if not all, the philosophies concerning the origin and causes of climatic change and of fluctuations of flood and drought, heat and cold.

Among the many additions to the first edition of 1926 is the inclusion of Professor F. E. Zeuner's views on the timing and glacial history of the Quaternary Ice Age. Zeuner adopts Milankovitch's theory of the changes in the obliquity of the ecliptic, that is the angle which the plane of the equator makes with the plane of the earth's orbit. The obliquity is regarded as having changed according to a mathematically calculated time-rhythm and Zeuner argues that this rhythm of obliquity corresponds to that of the ice advances and retreats in the Quaternary Ice Age. Dr. Brooks is at pains to stress that Zeuner realizes that this astronomical theory of how the oscillations were determined in no way explains this ice age as a whole. The author does not neglect to discuss fully the earlier theory of changes in solar radiation which Sir George Simpson puts forward to explain these oscillations.

Many of the factors which govern climatic changes through the ages are touched on and it seems probable that no single one by itself could possibly explain them. Short- and long-term changes may be due to different causes or a combination of two or three of them.

Besides discussing causes and timing (he devotes an appendix to geological dating) of climatic changes and fluctuations, he gives a wealth of evidence, geological and palaeontological, geographical and oceanographical, and to this he adds an excellent summary of accumulated knowledge of climatic changes within historical times, that is within the period commonly called the Post-Glacial or Recent. These records are based on many written accounts of, for instance, great cold or floods and other phenomena which are described or mentioned in literature; but before the time of written annals, archaeology and tradition are largely relied upon as a source of information supported by changes in lake levels and the study of tree rings and other physical phenomena.

It is impossible to give even a brief review of this concentrated wealth of information upon a study which involves so much and so many sciences. This in itself is a testimony of the value of such a work to the student, be he meteorologically or geologically minded. It might be added that it is also a testimony to the writer's patience, memory and clear-headedness—and, indeed to his life-long interest in the inter-relationship of earth and sky, and in the interpretation of historical and geological inferences of climate and weather.

The book requires hard concentration to read, which is indeed no fault of Dr. Brooks's easy style, but is simply due to the complexity of this fascinating subject.

C. D. O.

* Review.

A FIRST BOOK OF METEOROLOGY*

86 pages
20 half-tone illustrations
17 diagrams

By Arthur J. Starr
G. G. Harrap & Co., Ltd.
London, 1949, *5s. 0d.*

This little book offers a simple explanation of the first principles of meteorology, intended for the general reader and for geography students.

The author has followed the normal plan, starting with *The Atmosphere* and following with chapters on *Winds*, *Clouds*, *The Weather*, *Visibility* and *Observations and Measurements*. The final three chapters are *The Weather Map*, *Pressure Systems and their Weather* and *Weather Forecasting*. It is evident that so wide a scope could only be achieved by a superficial treatment and the author claims no more than this ; he has set out to whet the reader's appetite for further study rather than to write a comprehensive treatise.

It is unfortunate that this work should have appeared at the present time when the International Code has just been changed. As a consequence, many references to codes and scales are already out of date.

In an elementary text catering for the layman, the use of good diagrams may save lines of explanation. Most textbooks are sadly lacking in this respect and this one is no exception ; in fact some of the diagrams are particularly bad—the author would have perhaps been wiser to reproduce well-known standard diagrams. Figure 30, *Vertical Section of Frontal System* is most misleading. The only synoptic chart shown is a non-frontal one.

There are several minor points which might be improved in any further editions. For example, on page 22 the sentence "The effects of the earth upon its axis, etc.", should read "The effects of the rotation of the earth upon its axis." It is unusual too, to see Coriolis force defined in terms of pressure gradient instead of velocity. In the chapter on clouds, the height limits are not the ones usually quoted and there seems to be no advantage in those adopted by the author. Some mention might be made of *States of Sky* —a concept vital to modern observing practice. On page 60 it is stated that the wind blows along the isobars with an inclination of 35-40 degrees towards the region of lower pressure. In the reviewer's experience this deviation is excessive, especially over the sea.

The book includes *recapitulation questions*. While some of these are mere tests of accurate reading others are more ambitious and could hardly be answered adequately from the information given in the book. For example : "Explain the value of the synoptic chart to a forecaster" and "What are the main problems which confront the forecaster ?" Anybody able to answer these questions satisfactorily, might well claim to have a good knowledge of meteorology.

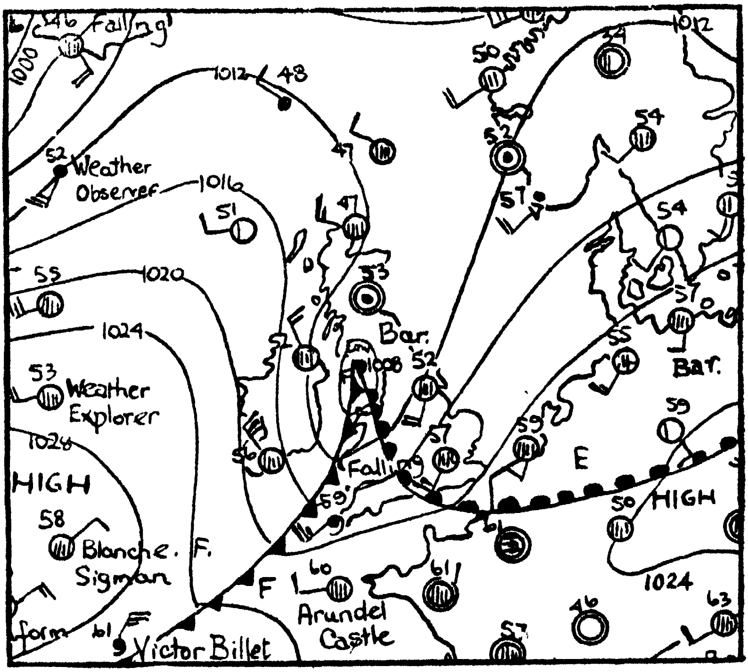
The book's appeal for the general reader must rest in its simple and straightforward style rather than in any attempt to "sell" the subject. The quality of paper and the standard of printing are both very good.

T.H.K.

* Review

"MUCH HILL FOG"

Those of our readers who are hikers, cyclists, or members of the various out-of-doors organizations such as the Youth Hostels Association will be especially interested in the photographs published opposite; they represent what the 'Airmet,' forecaster is pleased to call "much hill fog", and show how rapidly the weather on the hills may fluctuate. To the meteorologist they are an example of warm-sector fog and stratus cloud at the point of occlusion in the centre of a fast-moving depression. The photographs were taken at Gillamoor, Yorkshire, on September 15, 1948; the *Daily Weather Report* for that day shows a small depression with well-marked temperature differences between the warm sector and the following air mass (warm sector 59° F, polar air behind the cold front 50–53° F). The centre of the depression on the 06.00 G.M.T. chart was near Carlisle; during the morning of the 15th it moved south-east to East Yorkshire, bringing with it rain, drizzle and fog. The first



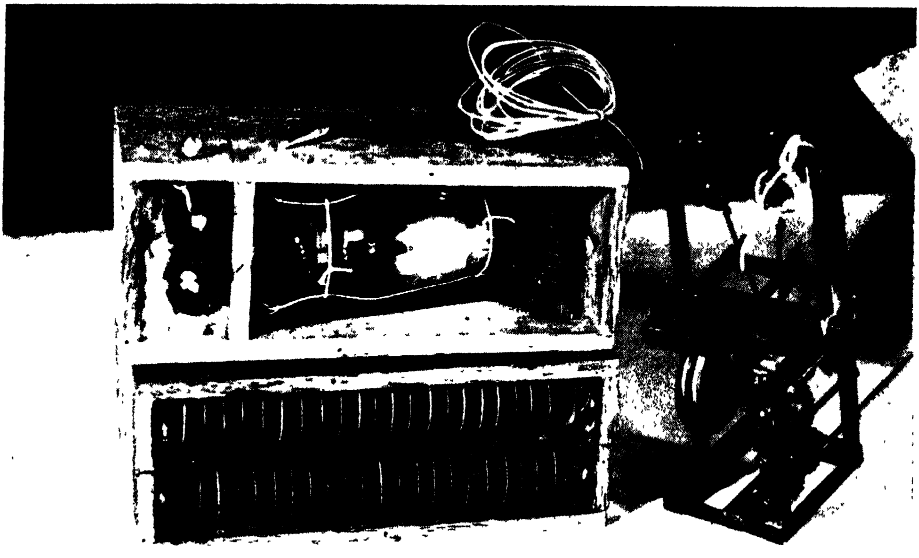
By permission of H.M.S.O.

Fig. 1. The Weather Chart at 06.00 G.M.T., September 15, 1948

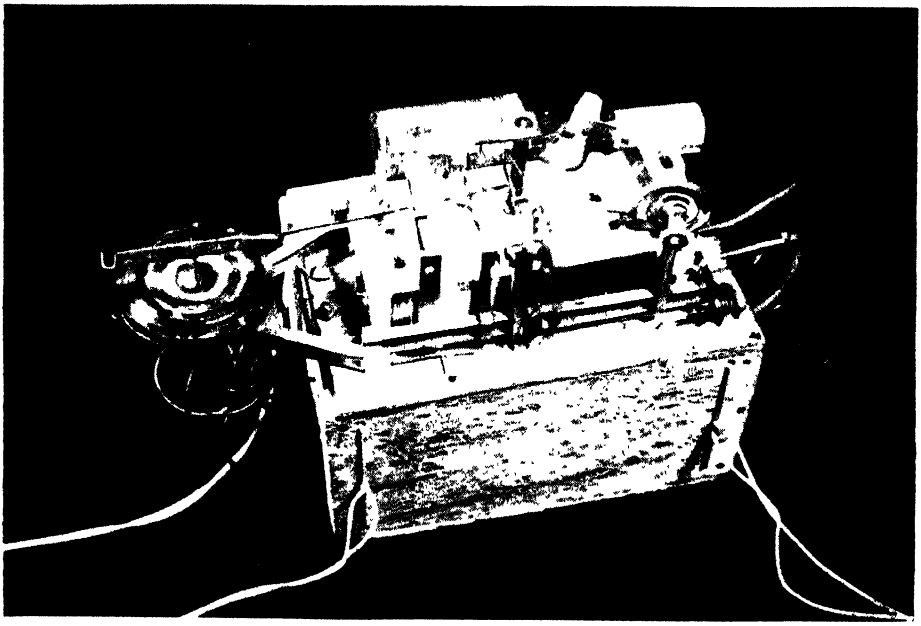
photograph was taken at 1.5 p.m. in the central zone, in continuous rain. The air was "muggy", the wind light SSW.-ly. This type of weather persisted until 2.30 p.m., when the cold front passed. There was an immediate freshening of wind from a NNW.-ly point, accompanied by a fall in temperature. The rain ceased, and the thick altostratus overhead thinned and broke, moving away eastward as a distinct line. The sun came out in an almost clear sky; visibility improved within a matter of minutes, as the photograph taken at 2.45 p.m. shows. It was a "text-book" example.

C. A. Wood

In the warm-sector, at 1.5 p.m. — same view as below



A. Fan-type radiosonde with transmitter and high-tension battery in box
(All parts except valve made in India)



B. Clock-type radiosonde fixed on transmitter box
(All parts except valve made in India)

PLATE II

DEVELOPMENT OF METEOROLOGICAL INSTRUMENTS IN INDIA

By K. S. AGARWALA, M.Sc., LL.B.
Indian Meteorological Service

During the past two decades or so, a considerable amount of work has been done on the development and designing of new meteorological instruments in India. An attempt has been made here to review briefly the work so far carried out in this direction.

Investigations on the design and construction of meteorological instruments in India have been undertaken mainly by the officers of the Indian Meteorological Department which possesses two well-equipped workshops—one at Agra (now transferred to New Delhi) and the other at Poona. Besides the Meteorological Department, the Mathematical Instrument Office at Calcutta is another Government institution which has done valuable work in this respect.

INSTRUMENTS FOR UPPER AIR MEASUREMENTS

A pioneer in the development of meteorological instruments in India was the late Mr. J. H. Field. Under his guidance the technique of pilot balloon observations and sounding work for the investigation of the upper air was developed at the Upper Air Observatory, Agra (1). Mr. Field's work was continued and extended by the late Rai Bahadur G. Chatterji, who achieved great distinction as a designer of simple and inexpensive meteorological instruments for upper air soundings. He produced temperature indicators, based on the principle of the bimetallic thermometer, for use in the first few kilometres above the ground (2) Chatterji also designed a hygrograph for obtaining continuous records of dry- and wet-bulb temperatures in the lower levels of the upper atmosphere. Another instrument constructed by Chatterji (3) is an improved type of the Dines meteorograph (Figure 1), which is particularly suitable, on account of its enlarged scale, for sounding the lower layers of the atmosphere. This instrument has been widely used in this country together with an inexpensive type of balloon, also developed by Chatterji; the balloon is made of " Vultex " tissue and has been found useful for attaining high ascents at low cost. Chatterji (with Neogi) also developed ingenious contrivances known as " pen-releases " for lifting the pens off the recording plate of the Dines balloon meteorograph during its descent, so that the pens may not blur the record when the instrument strikes the ground at the end of the descent (4). A set of inexpensive instruments has been designed by A. K. Das (5) for obtaining quickly the values of temperature and pressure and the heights of inversions in the lower layers of the free atmosphere. Das's instruments are based on the principle of the air thermometer and can easily be made by anyone with some experience of glass-blowing.

The use of the radio meteorograph or radiosonde in western countries for observations in the upper air attracted attention in India before the outbreak of the recent war and gave rise to the problem of developing a radio meteorograph which may be suitable and cheap enough for Indian conditions. With

this end in view, Dr. C. W. B. (now Sir Charles) Normand, as Director-General of Observatories, set up a programme for the development of the radiosonde in India during the war and the work received full support and guidance from his successor, Dr. S. K. Banerji. The work progressed independently at Poona and New Delhi. An inexpensive and simple fan-operated radio meteorograph, adopting the principle of the instrument developed in France by R. Bureau,

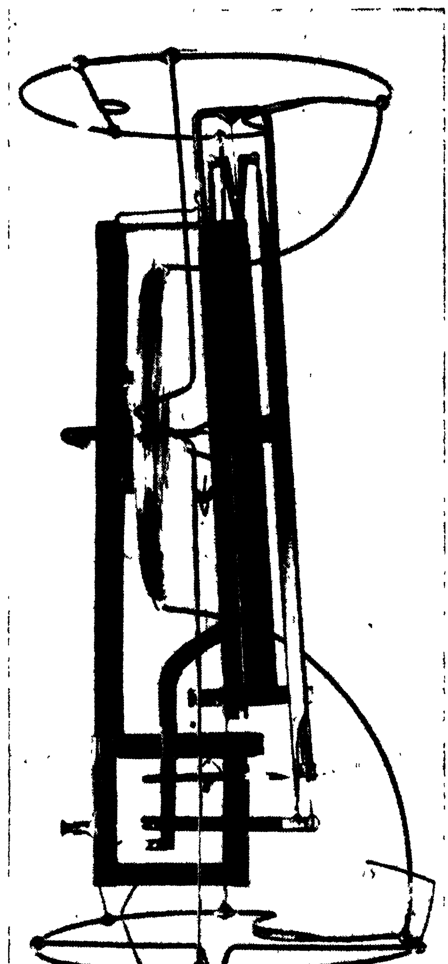


Fig 1. Sounding balloon meteorograph modified to give pressure and temperature scales about twice as large as those of the original Dines instrument

has been developed at Poona under the supervision of Dr. K. R. Ramanathan and is known as the Fan-type (F-type) radiosonde (Plate IIA). S. P. Venkiteshwaran and co-workers have recently published an account of this instrument (6). Another type of radio meteorograph has been developed at

New Delhi, employing the idea of Lange's radio meteorograph, and has been designated the "C-type" radiosonde (Plate IIB) on account of the use of a clock with it. Details of this instrument have been published in a paper by

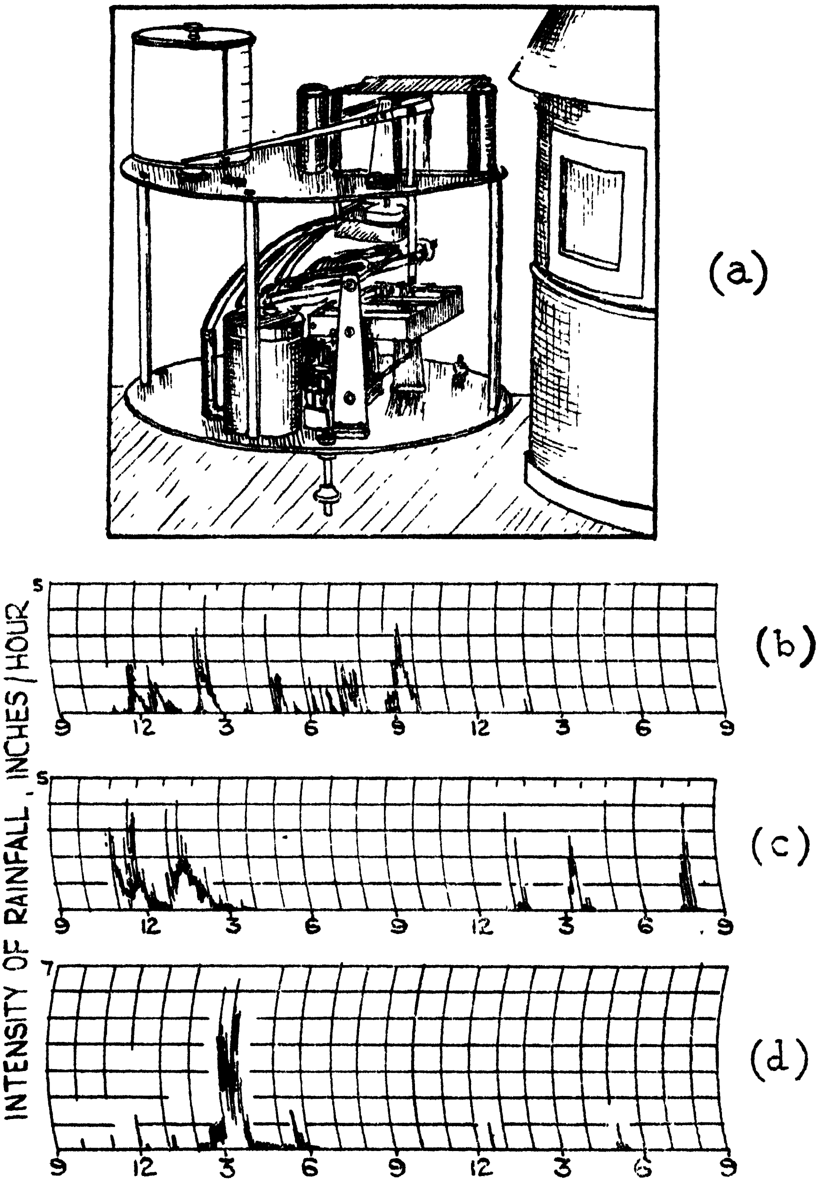


Fig. 2. (*a*) The Sil intensity rain gauge
(*b*) Rainfall record at Colaba, June 15–16, 1945 ; total 5·69 in.
(*c*) Ditto, June 20–21, 1945 ; total 5·88 in.
(*d*) Ditto, July 7–8, 1945 ; total 3·94 in.

L. S. Mathur (7). The technique of making the various components of these two types of radiosonde, e.g. clock movements, high tension cells etc., has also been developed at the Poona and New Delhi workshops.

INSTRUMENTS FOR SURFACE MEASUREMENTS

At the Poona Instruments Section a number of surface observatory instruments have been developed. The most notable contribution is the invention of an autographic intensity rain gauge (Figure 2) by J. M. Sil (8). This instrument records intensity of rainfall against time on a daily chart and employs three receivers with floats operating a common pen-arm. The instrument is sensitive to 0·02 inch of rain per hour.

A set of eye-reading wind instruments, commonly known as the " I.Met.D." cyclometer-type cup anemometer and " I.Met.D." windvane, have also been evolved at the Poona workshop under the direction of J. M. Sil. Initially, I.Met.D. cup anemometers (9) were constructed by remodelling old and unserviceable dial-pattern anemometers; the old dials were replaced by small counters, and ball-bearings were provided at the top of the rotating spindle. Later, this instrument was redesigned and further improvements were made. The I.Met.D. windvane (10) is an improved pattern of vane with splayed tail and ball-bearings. Both instruments have been giving satisfactory performance and are now in general use at all Indian observatories. Sil devised electrical anemometers and windvanes by providing suitable attachments to the ordinary instruments. Mention should also be made of some experimental work on the hot-wire anemometer carried out by S. Basu at Allahabad University.

Valuable work has been done by L. A. Ramdas (11) with his co-workers and students at the Poona Agricultural Meteorology Section and they have developed a number of new instruments suitable for measurements of meterological elements. Particularly noteworthy are the " Portable Standard Thermo-couple Set " for the measurement of plant temperatures; the " Soil Evaporimeter " for studying the variation in the rate of evaporation from soil surfaces with the sub-soil water at different depths; the " Temperature Alarm Apparatus " for use in a farm or garden to indicate the approach of frost; and a simple " Percolation Gauge " which is useful for studying the water-holding capacity of and the percolation through different soils. In addition, Ramdas and Joglekar (12) have designed a thermal filter for removing suspended particles in air or water.

In the same Section, A. U. Momin (13) has developed an " Electronic Integrating Solarigraph ". Momin (14) also recently read a paper on the cathode-ray tube spectrograph for studying the absorption bands in the solar spectrum.

The Mathematical Instrument Office (M.I.O.), Calcutta, has for many years prepared and supplied standard 5-inch rain gauges and measuring glasses to the Indian Meteorological Department as well as to the provincial rain-gauge stations. Until the provision of necessary facilities in the department itself,

the barometers of the Meteorological Department were repaired and cleaned at the M.I.O. which is also responsible for the supply of some types of the meteorological instruments in use in India.

SEISMOGRAPHS AND SPECTROGRAPHS

A number of instruments which belong to the fields of seismology and astrophysics have also been developed by Indian meteorologists.

Reference may be made to the important work of Dr. S. K. Banerji (15) on hydraulic seismographs. Recently the Indian Meteorological Department has undertaken the development of seismic instruments suitable for Indian conditions ; a horizontal strong motion seismograph of the Jagger pattern embodying some improvements has been constructed and tried (16).

Dr. A. L. Narayan (17) has developed a precision direct-reading spectrophotometer which has been used with success for a study of the radiation from sunspots and the surrounding photosphere. A simple cylindrical lens spectrograph for the optical determination of the concentration of ozone in the atmospheric layers near the ground was devised by M. W. Chiplonkar (18) under the guidance of Dr. K. R. Ramanathan.

Before concluding, the hope is expressed that India's contribution to the development of meteorological instruments will continue in an ever-increasing measure in the years to come.

The writer wishes to express his thanks to the Director-General of Observatories for kindly reading the manuscript of this article and for helpful suggestions.

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STRUCTURE AND DYNAMICS OF THE THUNDERSTORM

PART I

By HORACE R. BYERS, Sc.D.
University of Chicago

The Thunderstorm Project, a joint undertaking of the U. S. Weather Bureau, the U. S. Air Force, the U. S. Navy, the National Advisory Committee for Aeronautics and the University of Chicago, was designed to obtain the knowledge to make flying in thunderstorm conditions safe. During the war a number of fatal accidents in commercial and military flights through thunderstorms emphasized the need for the study. By the time the war ended, plans had been laid for the project, and with liberal funds appropriated by the Congress and with the support of all interested agencies, an intensive programme of observation and measurement was begun. In the summer of 1946 the observations were carried out in Florida, then in the summer of 1947 a similar programme was completed in Ohio. Since that time the analysis of the large amount of data collected has been performed by a group of meteorologists at Chicago and a comprehensive report of the findings will be published soon. It will contain information not only of use in flight operations but also in offering solutions of problems of thunderstorm structure and dynamics which have puzzled meteorologists for years.

In the following paragraphs will be given a brief description of the project and a summary of some of the results.

SYSTEM OF OBSERVATIONS

Basically, the observation programme was designed to obtain a complete description of the thunderstorm and to measure its intensity. The turbulence or bumpiness and the broad up-and-down motions of the air were considered to be the most important items to be investigated, but great stress also was laid on all measurable quantities that could give a clue to the vertical and horizontal air circulations and to the heat exchanges that drive these circulations and produce the rain. Lightning, which has been one of the main subjects of interest in many years of investigation by physicists and meteorologists, was considered to be of secondary importance, although arrangements were made for measurements of the cloud electricity.

In its main details the observation system consisted of the following :—

1. Airplanes were used as probes to measure turbulence, updrafts and downdrafts, temperature, electrical field and to obtain visual data such as hydrometeors, cloud extent, etc. Northrup Black Widow night fighters (P-61) were used, flown by some of the Air Force's most expert instrument pilots, who volunteered for the task. In a normal mission, five airplanes made simultaneous traverses through the thunderstorms at five different levels, namely 5,000 ft., 10,000 ft., 15,000 ft., 20,000 ft. and 25,000 ft.

2. A surface micro-network was established, consisting of 55 stations located one mile apart in Florida and two miles apart in Ohio. The stations were

equipped with gust-recording anemometers and wind vanes, hygro-thermograph, weighing rain gauge and barograph. The clock speeds on these instruments were fast enough to permit a time resolution to nearly a minute in most cases. The stations were attended daily by observers who travelled through the network in jeeps.

3. In and around the surface micro-network were set up six radiosonde stations with radio-direction-finding equipment (rawinsondes with RDF equipment SCR-658). Outside the network were four radar wind-finding stations, using small radar-target-bearing balloons. All of these stations made simultaneous balloon releases from which could be obtained, in addition to temperature and humidity data, detailed information concerning the perturbed horizontal wind flow, especially the horizontal inflow and outflow, of the cumulonimbus cloud.

4. Long-range radar was used to detect the development of thunderstorms, to select the storms for study and to guide the pilots and the balloon releases. The airplanes carried transponder beacons by means of which they could be identified separately and traced on the radar 'scopes even when inside the cloud echoes. The pilots were vectored through the storms by the flight controller who, stationed at the ground radar 'scopes, could watch their movements in relation to the thunderclouds. Radar also was used to study the development, growth, movement, distribution and dissipation of thunderstorms. In this connection, range-height-indicating radar was also employed, giving a vertical cross-section through the clouds and affording an opportunity to study the rates of vertical growth. All 'scopes were photographed every few seconds.

5. Time synchronization afforded the means by which all observations from airplanes, surface balloon recordings and radar could be tied together to give the instantaneous and progressive picture of the atmospheric processes.

STRUCTURE AND LIFE CYCLE

In the analysis of the airplane data it soon became apparent that in the usual large thunderstorm the pilot was encountering areas of strong turbulence each surrounded by a narrow belt of smooth but cloud-filled air. Roscoe R. Braham, Jr., Thunderstorm Project analyst assigned to this problem, recognized these as distinct convection cells which had become more or less joined together or developed as appendages to an original " mother " cell. For example, a typical Florida thunderstorm that was studied was found to be 20 miles long and about 5 to 8 miles wide and to have six recognizable cells within it. These were roughly oblong areas measuring 3 to 7 miles across. Between each cell the airplane, although still in heavy cloud, recorded a smooth portion having a width of about a mile or less.

An examination of the photographs of radar echoes returned by the thunderstorms through their life histories verified the cellular structure by showing the joining or growth of these cells occurring in much the same way as the growth of masses of certain kinds of bacteria. Where the cells were present over the surface micro-network, they could also be identified in the rainfall

pattern which, at any given moment, had a distribution corresponding to that of the cells. A separate rain maximum would appear under each cell. Other meteorological elements were found to fit the cellular pattern as independently obtained by the airplanes.

The cells were not all alike in structure. Some were found to consist of an updraft only; some had both updraft and downdraft, while others contained only a downdraft. These differences were recognized as being associated with different stages in the development and dissipation of the cells. From these studies, the life cycle of the thunderstorm cell was worked out, and it was immediately apparent that a thunderstorm usually contains cells in different stages of the life cycle. While every storm must be one-celled at the beginning, the simple unicellular type was found to be rare because its period as a solitary cell lasts only a few minutes after it has reached rainy, thundery conditions. Thus the text-book diagram of a thunderstorm, always unicellular, is misleading.

Part II of Professor Byers' article, dealing with the conception of cell development in thunderstorms, will appear next month.

ROYAL METEOROLOGICAL SOCIETY NEWS

At the meeting of June 15th, Professor David Brunt was very warmly congratulated by the Society on his recent nomination as a Knight Bachelor in the Birthday Honours. He was about to present a paper by E. M. Hewson on " The dissipation of scattered and broken cloud " (*Q.J.*, Vol. 74, p. 243), but he paused to thank his audience and remark that with the many kind messages of congratulations he had received he felt he was living in a slightly unreal world where it was always after dinner.

The question of the behaviour of clouds during subsidence, he said, went back at least to 1936, when Dr. Hewson's first paper appeared on the subject (*Q.J.*, Vol. 62, p. 387). He showed by means of tephigrams how Hewson's criterion of the ξ line operated, where ξ is the sum of the water vapour, the liquid water, and the ice associated with 1 gramme of dry air. He showed also that if the ξ line and the cloud line on the tephigram did not intersect the cloud could descend to the ground without being dissipated.

He then became D. Brunt (as Sir Robert Watson-Watt, the President, put it) and opened the discussion by confessing that he had not seen this phenomenon, but perhaps some of his audience had seen it in odd places he had not visited. The question at issue was whether we believe that these are the essential features in the dissipation of clouds. For one thing, Dr. Hewson himself had shown that for a typical cooling descending cloud the heat could not be lost by radiation in much under 6 hours, and in this time many things could happen. For another, Hewson's considerations involved the assumption that the only thing to subside was the cloud, and the air within it. But surely there would also be subsidence of the air beneath the cloud, and indeed airmen had observed this happening. In this case the dry air beneath the cloud would become warmer in accordance with the dry adiabatic, and very soon it would rise within the cloud itself and help it to dissipate. Clouds dissipating in this way would break up into rolls and vanish quite quickly and this would often be seen happening.

Mr. A. W. Brewer wondered whether Professor Brunt had been so far afield as NE. England, where sometimes in the late afternoon the forecaster's

lot was not a happy one. There was a choice of two environment curves, one of which foretold thickening and the other dissipation of the clouds. After some practice, however, it was possible to decide which to take.

The second paper, "Synoptic applications of the frontal contour chart: the motion of selected lows, 5-7 November, 1946," by A. M. Crocker (*Q.J.*, Vol. 75, p. 57) was read by Dr. J. S. Farquharson. He pointed out that frontal contour charts portrayed the intersections of frontal with isobaric surfaces and had been used from time to time by various authors—Bjerknes, Palmén, Van Mieghem and others. Their use had revealed that isolated domes of cold air more or less surrounded by fronts might exist from time to time. The author illustrated his paper by discussing the synoptic situation for November 5, 1946, over North America, with reference to a cold dome of this type. The subsequent development of an independent surface low on November 6 was also discussed and its movement shown to be controlled by that of the cold dome.

In the discussion which followed it appeared that synoptic meteorologists in this country preferred the use of the term "cold pool" rather than "cold dome," and Mr. A. G. Matthewman suggested that the low of November 6 was probably not originally frontless as suggested by the author. Mr. H. H. Lamb, also of the Forecast Research Division of the Meteorological Office, showed himself, with the aid of chalk and blackboard, a strong protagonist of the cold dome and frontal contour chart.

Mr. R. V. Radcliffe drew members' attention to the map he had displayed in the library on behalf of Mr. M. Bower of the Thunderstorm Survey about which several letters have appeared in *Weather*. The map showed the motion and intensity of activity of the severe thunderstorms which affected the western side of the country on August 1, 1948.

The President in closing the meeting announced that the Dining Club would not meet that evening as the numbers were too small. He expressed fears that the Club showed distinct signs of subsidence!

SCOTTISH CENTRE

Sir Nelson Johnson, Director of the Meteorological Office, addressed the Centre at a meeting held in the Department of Natural Philosophy, Edinburgh University, on Thursday, June 9, Mr. Paton presiding in the absence through illness of Sir Ernest Wedderburn. In describing the internal organization of the Office, the Director remarked that three quarters of his Deputy Directors were Scots, a piece of information which was obviously relished by the audience. The radio-sonde, wind finding by radio and radar, the sferic organization, weather reconnaissance flights and the scheme for maintaining a network of weather ships were all briefly described. The use of the upper air observations to construct weather charts for high levels and the practical use of such charts were explained.

Sir Nelson then gave short accounts of three current research problems: (*a*) the direct observation of water content in the lower stratosphere by aircraft of the Meteorological Research Flight using the Dobson-Brewer hygrometer, (*b*) the exploration of cumulonimbus by means of radar and (*c*) Sutcliffe's recent work which represented the first attempt to apply mathematical theory direct to the working charts of the forecaster.

THE WEATHER OF JUNE 1949

EXCEPTIONALLY DRY AND FINE

After a week of unsettled weather accompanied by a little rain in most areas during the first few days, the weather was remarkably fine. Sunshine totals were well above the normal nearly everywhere, parts of the Hebrides, for example, receiving an excess amounting to more than 100 hours. Swansea had the lowest rainfall for 28 years, while Kew had not recorded so little rain since 1938. The flow of water in the Thames was less than half the normal rate by the end of the month and appeals were being made to all water users to exercise economy.

From June 1 to 7 a west-south-westerly type of weather prevailed, occluded depressions filling up off our north-western seaboard, while associated fronts passed over Britain ; on the 6th a deep depression off the Hebrides caused winds of gale force in some exposed northern places. On the 8th a ridge from an anticyclone over central Europe covered the British Isles and a long spell of dry and settled weather had begun. Apart from about six days when eastern districts were cool, owing to air of northerly origin and to much cloud (Aberdeen reported the lowest minimum on record for June, 33° F. on 17th), the remainder of the month was warm. Temperature exceeded 80° F in the south from 27th to 29th, and so high a night minimum as 64° F on 28th at Kew had not been recorded since 1878.

Shortage of rain is not confined to this country. We learn that in the eastern part of Cape Province, South Africa, a new £35,000 reservoir completed last September is dry ; all springs near Bedford are also dry, and water has been limited to one hour a day since Christmas A heat-wave in New York was broken on 27th, but no end to the 33-day drought was in sight by 28th Widespread rain in western Canada early in the month reduced anxiety about crops, although it is still needed in Alberta and Saskatchewan, where serious outbreaks of grasshopper infestation are reported.

From Spain and Portugal, and also from Virginia, come reports of damage by thunderstorms, and flooding, as a sequel to drought, while feelings of sympathy will be extended to the many bereaved after the typhoon that swept Southern Japan around 20th. After the heaviest June rainfall since records were begun 64 years ago in Sydney, there have been the worst floods in the history of parts of New South Wales ; thousands of people were made homeless and electricity and gas supplies were seriously curtailed

	TEMPERATURE (°F.)				RAIN (mm.)*			SUNSHINE (hr.)		
	Long period Average		This month Extreme		Month	Diff. from Av.	Last 12 months	Month	Diff. from Av.	Last 12 months
	Max.	Min.	Max.	Min.						
Kew Obsy.	68·0	51·9	84	44	11	—46	454	235	+ 35	1605
Gorleston	62·6	51·1	80	42	11	—34	416	242	+ 33	1630
Birmingham	64·9	49·5	81	42	6	—53	677	230	+ 51	1415
Falmouth	62·4	51·4	†78	†48	16	—43	820	290	+ 63	1799
Valentia	61·6	51·4	74	42	74	— 5	1315	249	+ 76	1292
Aldergrove	63·2	47·9	83	36	15	—43	779	251	+ 74	1335
Holyhead	59·4	51·3	78	41	8	—47	700	292	+ 76	1593
Tynemouth	59·7	49·3	79	44	25	—25	477			
Renfrew	63·0	46·6	81	40	23	—33	1173	259	+ 84	1362
Aberdeen	59·7	45·1	72	33	42	— 3	694	236	+ 50	1539
Stornoway	57·0	46·7	71	38	26	—39	1280	271	+104	1234

* 25 mm. = 1 inch (approx.) † The Lizard C.R.B.

WEATHER OVERSEAS

NEW REPRESENTATIVES

We have pleasure in announcing the following additions to the list of Overseas Representatives published in our issue of May, 1949. One of the duties of our Representatives is to act as a link between contributors in their part of the world and the Editors, and it would be of great assistance if writers of articles and smaller contributions would submit them to the appropriate Representative whenever possible.

E. AFRICA: D. A. Davies, Meteorological Department/P.O. Box 931, Nairobi.
EIRE: F. E. Dixon, Meteorological Office, Dublin Airport, Collinstown, Co. Dublin.
PORTUGAL: H. A. Ferreira, Serviço Meteorologico Nacional, Largo de Santa Isabel, Lisbon.
W. AFRICA: A. G. Butcher, P.O. Box 744, Accra.

WORLD WEATHER RESEARCH

One of the recommendations approved by the Pacific Science Congress held recently in New Zealand was that of its Research Plans Committee in Meteorology for a programme of weather research on a world basis, including the establishment of pole-to-pole weather stations. The adoption of the recommendation is now followed by a statement by Mr. J W Hutchings, organizing secretary of the Division of Meteorology at the Congress, who also announces the appointment of an International Standing Committee on Meteorology. The members of this committee are: Dr. A. F. Spilhaus (United States) chairman, Dr. M A. F Barnett (New Zealand), Dr. H P. Berlage (Netherlands East Indies), Colonel T S. Moorman (United States), Dr. C H B. Priestley (Australia), Mr. R H. Simpson (Hawaii), Sir Geoffrey Taylor (England), and Dr. A. Thomson (Canada). In his statement Mr. Hutchings says that steps have already been taken to put into practice the programme of world weather research recommended by the Research Plans Committee in Meteorology of the Congress. Several of the stations on the proposed pole-to-pole chain are operating at the moment, but new upper-air research stations must be established at Little America, in the Antarctic, on Norfolk Island, the New Hebrides, Guadalcanal, Bougainville, Tarawa, and so on in a line northwards. Gaps in this line would be filled by weather ships. The weather stations, says Mr. Hutchings, would record not only the passage of surface air but general movement in the atmosphere up to a height of several miles. The weather ships would also probably take temperature, pressure and other recordings deep down in the ocean. It is considered that the establishment of chains and networks of weather stations would not only help in day-to-day weather forecasts but would facilitate research into recurring fluctuations in the weather. In some parts of the Pacific weather recurs in a three-year cycle. But some day, when more is understood about long-period variations in weather, it might be possible to forecast a good or a bad season for different crops.

NEW ZEALAND'S RAINFALL DECREASING

Dr. C. J. Seelye, of Victoria University College and lately in charge of climatology for the New Zealand Meteorological Service, says weather reports for the whole country over the past 100 years show that New Zealand's rainfall is decreasing; the estimated rate of decline in the North Island is 4 per cent for the century and in the South Island 2 per cent.

CONTROLLING THE WEATHER

"ATTABUBU, (N.T.) July 30 . . . .

Two young men charged before the Native Court here with committing an offence against custom by tying the rain and preventing it from falling pleaded guilty and were fined £5 each which they paid without question.

They admitted that they had acted very selfishly. In accordance with custom two sheep were slaughtered. The rain naturally began to fall and no further meteorological trouble has been experienced since."

The above extract from a West African newspaper illustrates some of the difficulties experienced in trying to forecast the weather in certain parts of the world. It seems that "dry ice" is an unnecessary complication in trying to produce rainfall !

DUBLIN METEOROLOGICAL AND GEOPHYSICAL SEMINAR

A seminar with the above title has recently been started by Dr. L. W. Pollak, Senior Professor of the School of Cosmic Physics in the Dublin Institute of Advanced Studies, in collaboration with Dr. M. Doporto, Director of the Irish Meteorological Service. The first meeting, on May 5, heard an account by Dr. P. J. Nolan of "The size and charge distribution of atmospheric nuclei", and saw a demonstration of the improved nucleus counter developed by Dr. Nolan and Dr. Pollak. On June 2 the subject was "The prehistory of the Earth's magnetic field," by Asst. Prof. T. Murphy. Attendances were good and the venture seems likely to be most helpful to all in Dublin interested in meteorology and related branches of geophysics. The programme for the remainder of 1949 includes :—

Oct. 6. Prof. L. W. Pollak—Tests of significance in periodography.
Nov. 3. Dr. T. E. Nevin—The spectrum of the night sky.
Dec. 1. Dr. M. Doporto—On hydrodynamic instability in the atmosphere.

BIRTHDAY HONOURS

Readers of *Weather* will be delighted to know that, in the King's Birthday Honours, Professor Brunt was created a Knight Bachelor (see Royal Meteorological Society News, page 222).

It is with pleasure also that we announce that Mr. F. D. Napier, instrument maker charge-hand of the Instruments Development Branches, Meteorological Office, Harrow, has been awarded a British Empire Medal.

WEATHER LORE

Readers may be interested in a broadcast discussion on "Weather Lore" to be transmitted on the Home Service of the B.B.C. on July 15 from 7.30 to 8 p.m. The following will participate :—

Mr. E. G. Bilham, Mr. Raymond Bush, Instr. Capt. J. Fleming, D.S.C., R.N., and Mr. Ralph Wightman.

A Weather-Ship's Lullaby

Rockall-by-Bailey : on the sea-top
When the wind blows, the "Observer" will rock !
When the storm breaks, there'll be such a squall,
Down will come Radar equipment, and all !

W.E.L.

AREAS USED IN WEATHER BULLETINS FOR SHIPPING

Several enquiries have been received about the names of the areas used in shipping forecasts, a map of which was reproduced in the January 1949 number of *Weather*, p. 30.

The areas formerly in use for many years were revised and extended as from November 1, 1948, and some new names were introduced. To anyone who has access to an Admiralty Chart the reasons for the choice of many of the names will be evident enough. The predominantly coastal areas are named after what is probably the factor of major geographical significance to the mariner, thus : the Firths of Cromarty and Forth and the Bay of Biscay ; the rivers Tyne, Humber, Thames, Shannon and the Irish Sea area ; the ports of Dover, Portland and Plymouth ; the islands of Heligoland, Wight, Lundy, Hebrides, Faroes, Fair Isle and the rocks of Fastnet and Rockall ; the headlands of Finisterre, Malin and the area adjoining South-east Iceland. If an area is not close to a coast line and does not include an island, the only significant feature on the chart is a comparatively shallow or deep locality, known to cartographers and seamen as a "bank" and a "deep" respectively and often given a name.

" Forties " is the name given to a fairly large area between Scotland and Norway where the soundings are mostly between 40 and 50 fathoms.

" Dogger " is a bank between Southern Scotland and Denmark. To geologists this Bank or submerged plateau is of especial interest for its northern edge marks what used to be part of the coast-line of North-West Europe in about 7,500 B.C. when England was joined to the continent, while evidence of life at that time is provided by objects of human workmanship and bones of such animals as bear, elk and woolly rhinoceros that have been recovered by trawlers. The Dogger Bank was the scene of a battle cruiser action in World War 1 when Admiral Beatty's ships sank the German " Blucher ". It was probably given the title of " Dogger " at a time when it was a favourite hunting ground for a Dutch type of fishing vessel with that name

" Sole " is named after the Great and Little Sole Banks in approximate position 49°N., 9½°W. History does not relate why the French gave the banks these names, but we are assured that it is not, nor is it known to have been, a particularly good place to catch flat-fish.

" Bailey " is so-called because of the two shallow patches outside the 100-fathom line, one of about 64 fathoms and the other of 95, in approximate positions 60½°N., 10½° and 12½°W. respectively The following extract from a letter from Mr G. T. Atkinson of Lowestoft, who has seen many years service with the Ministry of Agriculture and Fisheries, explains how and why : "As to the origin of the names I can give you the newest—Bailey. Do you remember late in the Victorian (or was it the Edwardian) era when every errand boy whistled and everybody sang the popular song ' Won't you come home Bill Bailey . . . .Bill Bailey won't you please come home ? ' A Grimsby steam long-liner was exploring the series of banks which lie between the Faroes and the Hebrides They were quite unknown to the ordinary navigator, but there were a lot of halibuts living there and for a time he and friends to whom he revealed his discovery did very well. To give it a name nothing seemed better than the popular song of the day. (There are two " Klondyke " fishing banks dating from the time the gold rush of '98 was on. These trawling grounds in their virgin state were very rich) ". Of the two banks in this forecast area, the shallower is known as " Bill Bailey's Bank " and the deeper as " Outer Bailey or Lousy Bank". The alternative name aptly describes the weather for much of the year in these waters.

C. R. Burgess

NOTE ON THE EVIDENCE FOR CLIMATIC CHANGES FROM SUB-OCEANIC CORES

By C. D. Ovey, B.Sc., F.G.S.

British Museum (Natural History)

That climatic changes are reflected in the type of sediments and the faunal contents of cores taken from the ocean floor is now firmly established. Cores of up to nearly three metres in length, taken by Dr. C. S. Piggott in 1936 on board the cable ship " Lord Kelvin " in an approximate line across the North Atlantic from the Newfoundland Banks to the continental slope off the south-west of Ireland, revealed alternating layers of glacial marine beds and warmer oozes (Bradley *et alia*, 1942). It is estimated, however, that these cores would only cover the period of the last major advance of the ice age—the Wisconsin of America or the Würm of Europe. Similar climatic changes have been identified by cores studied by Dr. W. Schott from the equatorial Atlantic during the " Meteor " Expedition and, according to Professor Pettersson (1949), between Madiera and Martinique, by Dr. F. B. Phleger from the east coast of America and the Mediterranean and by Dr. H. G. Stubbings from the Indian Ocean.

With the recent return of the Swedish Deep-Sea Expedition, under the leadership of Professor Hans Pettersson, much valuable information is expected which may prove to be revolutionary to our present knowledge of glacial and post-glacial climatic fluctuations, for a new corer was used on board the "Albatross ", invented by Dr. B. Kullenberg. This apparatus, known as the Kullenberg piston core-sampler, could penetrate to the unprecedented depth of some 15 metres (Wiseman, 1947).

Only recently Dr. G. E. R. Deacon at a joint discussion of the Royal Meterological Society and the Royal Astronomical Society indicated the reliability of sub-marine cores in showing post-glacial climatic changes. It would seem that such evidence could far more easily be interpreted than any provided on land whether geological or physiographical, or from any obtained from the fossil remains of flora or fauna.' On land there were too many disturbing influences such as erosion, the recent accumulation of alluvium, vegetation, and even the effect of human civilization masking the truth. Under the ocean, on the other hand, sedimentation was usually continuous, irrespective of whether the surface waters were at one time swept by predominantly tropical air masses or by polar air bearing drifting ice and icebergs to much lower latitudes than today. The further from land, the slower would be the rate of accumulation of bottom sediments—an important fact, for 15 metres of core taken in the remote deep water would give evidence for a greater period of time than any taken elsewhere.

THE EVIDENCE

In cores, evidence for climatic change is shown by several distinct types of deposits. For cold periods, where the currents at the ocean surface were cold and icebergs drifted to 30° latitude or below, beds rich in erratic debris are found. These beds pass laterally into red clay or oozes in regions free from drift ice. The time may come when petrological and palaeontological examination of some

of the mineral and fossil contents of marine glacial deposits will tell us whence came the melting icebergs which scattered their encased moranic material over wide areas of the ocean floor to build up these beds. Consider the significance of tracing the evolution of ocean currents by means of the drift direction of melting icebergs ! Ocean currents are a function of wind direction ; wind direction is a clue to pressure distribution which, in its turn, combined with our knowledge of the distribution of the extended ice caps during the major Pleistocene glaciations, would suggest where the main tracks of depressions travelled to bring the necessary snow to feed the ice caps in Scandinavia, Britain and elsewhere. This is a glimpse of the possibilities in tracing not merely climatic fluctuations but weather evolution since, perhaps, the beginning of the Pleistocene Period, a million or more years ago.

Warm periods are marked by calcareous oozes rich in the remains of the shells of minute marine protozoa known as foraminifera (see Plate IV). These minute creatures live widely distributed over the seas and oceans ; while far the greatest number of species live either on the bottom or attached to other marine animals or plants, a few are pelagic and form part of the swarming life, known as plankton, living in the surface layers and subject to the whims of waves and currents These are discernible, structurally speaking, through a microscope Certain of these species are characteristic of cold and others of warm waters, the latter always being far more abundant Those whose remains are found in the deposits between the glacial beds mentioned above indicate cool temperate surface water conditions, perhaps a little warmer than today in some instances In the tropics, distinctive tropical assemblages of them alternate with accumulations of cooler types corresponding to glacial deposits further north. The important fact about these temperature-indicating organisms is that their evolution has been so slow that many of their species have remained unchanged for the last 30 million years, ever since Miocene times, so that if the cores can be raised to give a continuous record of ocean sediments since those days, much valuable information will be obtained for the climatologist, geologist, geographer, meteorologist and a host of other scientists.

THE "ALBATROSS" CORES

The first of the Swedish Deep-Sea Expedition's cores has been examined for its foraminiferal content by Dr. F B. Phleger (1948). This core was raised in August 1947 from the floor of the Caribbean Sea, below 2,677 fathoms of water, and was 1,540 cm. in length. Although only 75 samples were examined, each a centimetre in thickness, the results clearly indicate alternating warm and cold periods (see Figure 1). It must be remembered that the faunal remains are a reflection primarily of ocean currents, probably within the upper 1000 metres, and not directly of climatic conditions : nevertheless it would be difficult to conceive how cold surface currents could flow into the Caribbean during tropical periods.

Dr. Phleger (1948) has suggested a tentative interpretation of his results on broad lines as is indicated in the righthand column of the diagram. He uses the nomenclature of four of the major American continental ice advances of the

Pleistocene—Nebraskan, Kansan, Illinoian and Wisconsin,—the fifth, the Iowan, not specifically designated here but usually recognised in U.S.A., might be included as the lower stages of the Wisconsin.

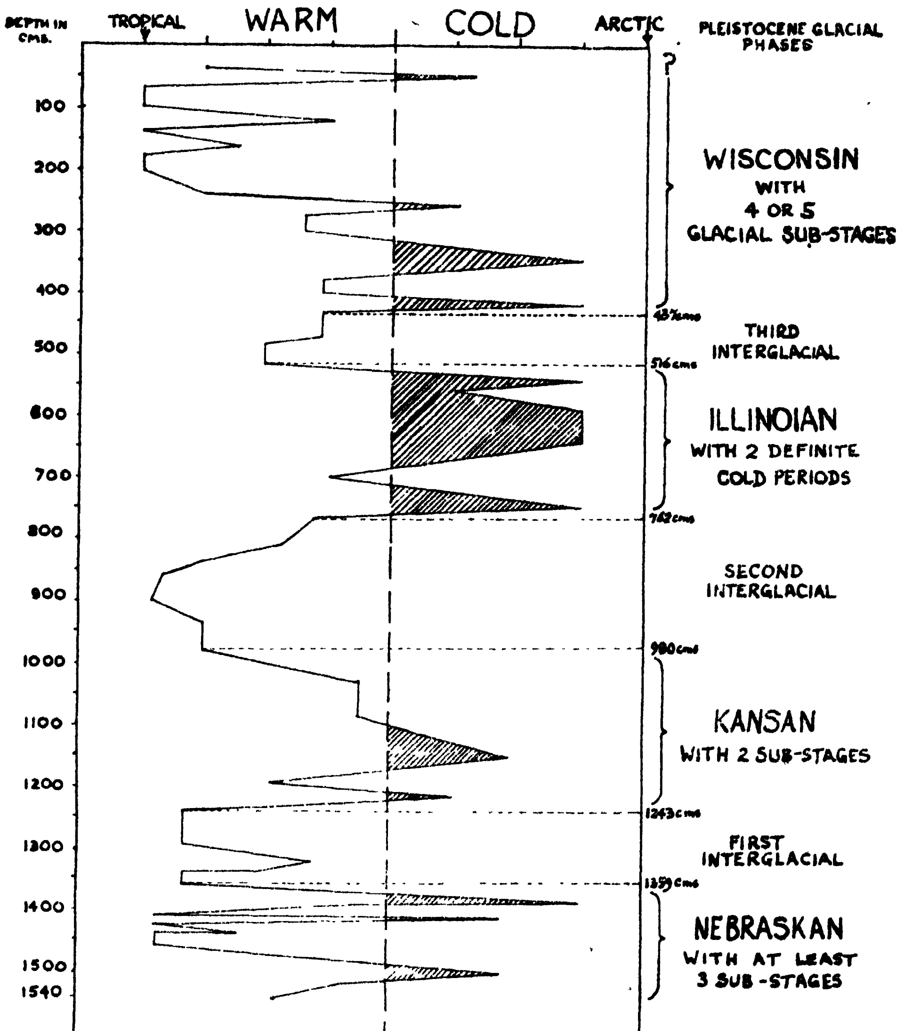
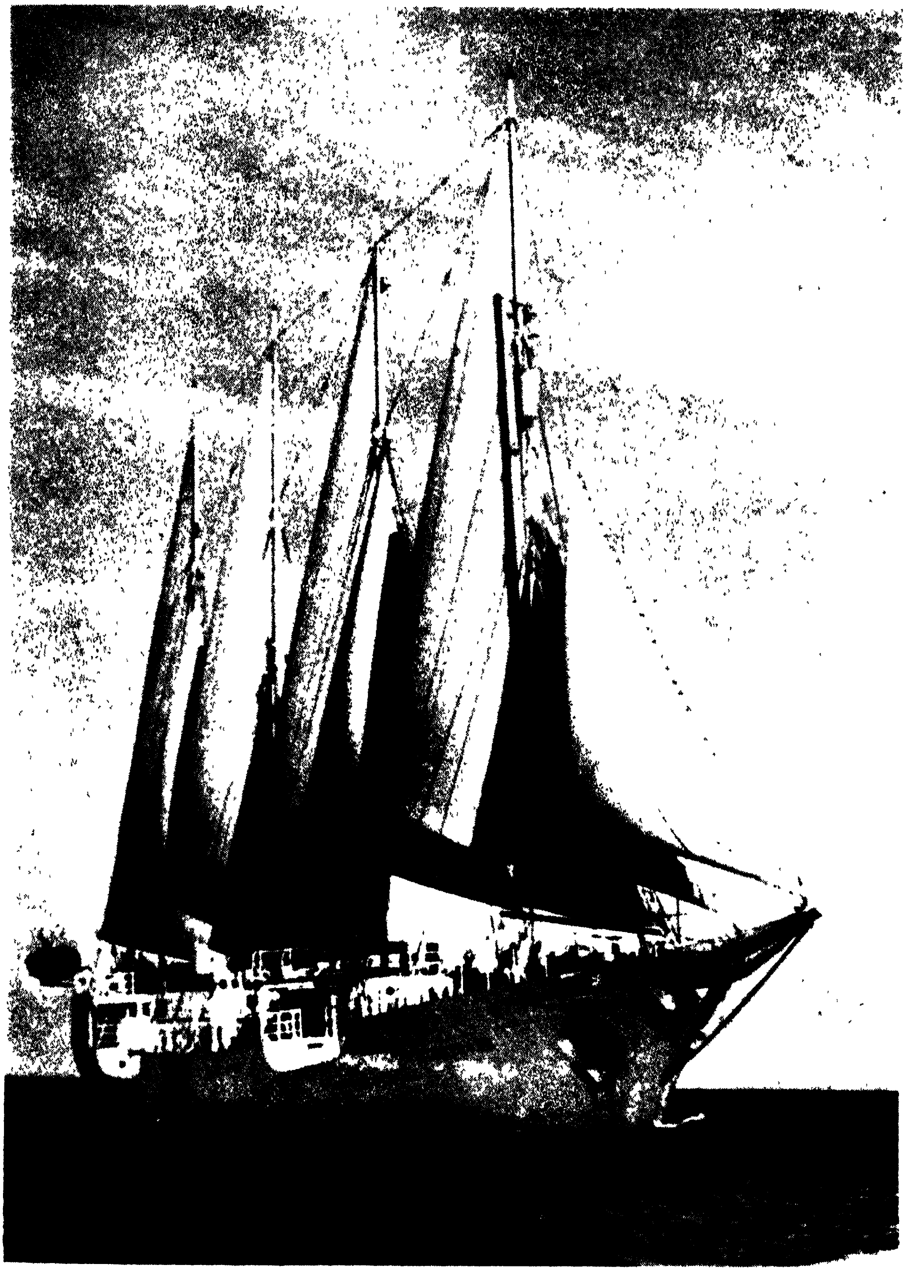


Fig. 1. Approximate relative changes in surface water temperatures, based on the percentage variations of cold and warm water foraminifera from core 34 (15.4 metres in length), "Albatross" Station 10 (1947), Caribbean Sea. The top few centimetres, representing about the post-glacial period, were in such a fluid condition that they were lost when the core was extracted from the coring apparatus. (Based on Phleger, 1948)

DATING OF CORES

The complexity of timing ocean cores has been greatly simplified recently by the Urry (1942) radioactive technique based on the ratios of the concentrations in the sediments of the non-equilibrium series uranium, ionium and radium,



THE "ALBATROSS"

The ship used by the Swedish Deep Sea Expedition 1947-48 for oceanographical research. The Kullenberg piston core-sampler used on this expedition has provided a total length of over an English mile of bottom cores. From these cores past climatic changes can be detected over a period of at least a million years and perhaps in places considerably longer

PLATE III

TEMPERATURE-INDICATING ORGANISMS FROM THE OCEAN

An example of the concentrated organic remains extracted from the surface of ocean ooze in tropical waters. The different species of shells of such marine protozoa (Foraminifera) reflect the temperature of the surface layers of the water in which they live, and are used in the study of ocean cores as indicators of past climatic change. Magnified 15 times

The inset shows a concentrate from a sample of deep-water ooze taken by the "Terra Nova" from the Ross Sea. The minute foraminiferal shells shown here in this cold water sample are in striking contrast to the assemblage from tropical waters. Magnified 8 times

Photographs by] [*M. G. Sawyers*

PLATE IV

assuming that the concentration of radioactive elements from the sea water or other sources has remained constant throughout the period of deposition. This method is likely to be more accurate in the deeper parts of the ocean where sedimentation is steady and not contaminated either by radioactive minerals brought in by river sediments or by local volcanic activity. In shallower water, too, the rate of sedimentation in a single core is likely to be extremely variable. Phleger suggests that tho possible rate of accumulation in the Caribbean core was in the order of one centimetre in 1000 years, making the whole period of accumulation over 15 million years.

INFERENCES

Many believe that major cold periods of the past were contemporaneous over the world ; some evidence for this has already been accumulated from core studies. Many minor cold fluctuations may have been more localized but this can only be proved by correlations of cores and tying up such evidence with geological information on land. Several things seem certain, however, from our present knowledge. Firstly, the tropics were colder than today ; normally icebergs in the cold periods flowed at least as far south as the Azores ! Secondly, the polar front was displaced southwards, a theory which supports the geological view that pluvial periods of the Pleistocene in the Mediterranean were concurrent with maximum ice advances over Europe, signifying the passage of depressions into the Mediterranean area as a prevailing meteorological phenomenon. Thirdly, the fact that glacial marine deposits have been found further south than the Azores and laterally from America to Ireland indicates drifting icebergs over the whole of the northern half of the North Atlantic. The source of the material in these deposits, as already mentioned, might be approximately traceable to their place of origin possibly in Greenland, North Eastern America, the British Isles or elsewhere.

To understand the origin of ice ages and lesser cold periods it is insufficient to trace the evidence from continental deposits and to attempt a basis for pressure distribution entirely on it. If the oceans can be made to divulge their secrets, the student of past climatic changes stands a far better chance to explain the phenomena on land but he will have to become acquainted with much literature which it is anticipated will eventually be forthcoming in the special studies of the many branches of science which are likely to be involved in the interpretation of the Swedish Expedition's cores. It is a pity, however, that we are unlikely to discover fossil upper winds to help in past climatic analysis !

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WARNING!

Unless serious attention is paid by the public to warnings to conserve water supply, particularly in SE. England, we may suffer before autumn one of the most disastrous water shortages in history. There are a number of circumstances which indicate this possibility, including the prevalent low level of wells and springs in the London Basin and elsewhere, and the repeated development of persistent anticyclones near the British Isles, although we are not yet in a position to determine the degree of persistence. Even should there now be a succession of wet days, evaporation is at its height, and there is a lag of three or four months or more before percolating surface water could raise the water-table and make it available in deep wells. The flow of the Thames at Teddington at the end of June was barely a quarter of normal.

G. M.

July 7 C. D. O.

LETTERS TO THE EDITORS

A Pilot-Balloon Ascent to 22 miles?

Recently I read a letter in *Weather* of August 1948 in which Mr. A. J. Wells describes a pilot-balloon ascent to a height of 22 miles. It is very interesting but I think it is very doubtful that the balloon actually reached such a height. In my opinion the balloon developed a small hole during the ascent which resulted in a reduced rate of ascent—it is not possible to be quite certain without investigating the graphical plot of the ascent.

Some time ago I published a note (*Időjárás*, Budapest, Vol. 52, 1947, pp. 19-26), on the errors in the computation of pilot-balloon ascents due to assuming a uniform rate of ascent. I showed that if the rate of ascent decreased the wind speed would apparently increase gradually and steadily and the path would appear to depart from the theodolite. It is sometimes possible to make some allowance for the reduced rate of ascent by a careful study of the graphical computation.

Budapest, Hungary ZOLTÁN OZORAI

Snow Cover in Summer

I send you the following comment on N. A. Field's letter in the May 1948 issue of *Weather* regarding snow cover until mid-July on the Cotswolds:

"It was a cove, a huge recess,
That keeps, till June, December's snow,
A lofty precipice in front,
A silent tarn below!
Far in the bosom of Helvellyn,
Remote from public road or dwelling,
Pathway, or cultivated land,
From trace of human foot or hand"

—From "Fidelity", by William Wordsworth.

C. A. WOOD.

Statistics and Meteorology

I would like to express my entire agreement with Rosini, in his view of meteorology as understood from the review of his work *Statistics and Meteorology* in the March issue of *Weather*. This dualism of method is too apparent to be ignored and I wholeheartedly support his belief that the middle course will prove to be the most profitable. The meteorologist must sometimes allow himself to come down from the upper air, where in vain he searches for scientific rules, to study on the earth's surface the pattern of actual occurrence.

Since the causes responsible for weather changes are so complex that even the expert sometimes finds it difficult to see which will preponderate, experience from close personal observation is essential. The key to a difficult day when weather types are changing over may more easily be found in analagous situations of the past than in present time conditions. It is surely foolish to maintain that the all-informed physicist with no more than a pecuniary interest in the weather is better equipped to forecast, than someone with years of experience of the weather and its synoptic situations, but less completely caught up in the web of mathematics. I am not decrying what one calls 'technical meteorology', but I feel it is progressing at the expense of knowledge gleaned from a personal understanding and contact with the weather, and I am sorry to notice *Weather* is following this trend.

Rosini mentions intuition. This unscientific aid, which is given only to weather's lovers, may be ridiculed by the orthodox meteorologist, but in my experience it has many times been blessed with success, particularly in long range forecasting. Does it deserve no place in forecasting ? Should it not be included in statistical meteorology, in forecasting based on durations of particular types of weather mathematically founded on laws of probability ?

Wimbledon N. S. GARDINER

Frost Warnings

I think the following may be of interest in view of the astonishing action of the B.B.C. announcer on April 30. After reading a 'frost warning' he went on to say that a similar warning had been issued the previous day but that there had been no frost anywhere, the lowest temperature having been 33° F. at Edinburgh. This statement was wrong and was subsequently corrected. As a gardener I am most grateful for these 'frost warnings', especially on an occasion like April 30. On that evening the sky was overcast, there was a sprinkling of rain and the temperature was about 50° F. The local indications were in fact against frost. But I had confidence in the warning and took action. Next morning, when I looked out, the coverings were white with frost, the plants beneath were uninjured.

On May 1, the local indications in the evening were for frost. The sky was clear, the wind was decreasing and the temperature, again about 50° F., was falling. In spite of this, the Meteorological Office cancelled a frost warning issued earlier in the day. However, I thought I would be on the safe side and I replaced the coverings. I need not have done so ; there was no frost at all.

London, N.W.11 E. GOLD

A Hot Day in April

April 16, 1949, Easter Eve, with a maximum of 84° in London, was acclaimed the hottest April day for more than a century, though it should be remembered that hot April days with temperatures bordering on 80° have become quite the fashion of recent years as notably in 1946 and 1947 quite early in the month. Hence the late Sir Robert Ball's words which I well remember reading in boyhood in one of the illustrated weekly's after a hot day in April 1893 as late as the 20th seems a little beside the point : " When before have we been able to read of temperatures of 78° and 80° and upwards in this century in the latter part of April ?"

In the South-West, where I was spending Easter, April 16, 1949 was not so hot as in the South-East but was sufficiently warm to occasion thirst after a longish country walk. At Honiton, Devon, patchy thundery showers in the evening grew out of castellated cumulus half-way towards real cumulus. I thought showers from this cloud structure somewhat unusual but they were evidently connected with actual thunderstorms in Cornwall.

On the train journey down from Waterloo on April 15, I took special care to notice that the woods were still mostly bare the whole way from Surrey to Devon, but on the return journey on April 20, the forcing heat was showing its effect in a definitely more forward state of the trees, species for species, near London than in the West.

Hampstead L. C. W. BONACINA

Dust Devil near Wellington College

It may be of interest to know that I watched, with a party of boys, a small dust devil near here on Saturday afternoon, May 14, at about 2.50 p.m.

It started in a corner of a field, sheltered by woods on the north and east, appeared about 10 ft. across at some 6 ft. above the ground, travelled west and was strong enough to disturb violently the branches of an oak under which it passed. It hit the spinney on the far side of the field and was there lost to view or died out. The sky was nine-tenths clear and the wind was negligible : thunder clouds gathered later.

The field is just west of Bramshill Park—O.S. New Pop. Edn., Sheet 169, ref. 748 600 on north bank of River Hart.

Wellington College, Berkshire L. M. LEAKEY

Airmet Interval Signal

Your correspondent E. L. Hawke has evidently not noticed that the short and long sounds of the interval signal spell the word 'airmet' in the Morse Code. Some sort of interval signal is surely necessary, as people may be trying to tune in to any of the 10-minute sections of the bulletin, perhaps on a not very selective receiver. The notes of the present signal are clear and distinctive and are as useful as the tuning signal.

Kensington, London, S.W.7 C. H. WILLIAMS

As the wife of an amateur meteorologist, I would like to congratulate Mr. E. L. Hawke on his article in the May issue of "Weather." From "morn 'til night", whenever I switch the radio on, the incessant sound of that feeble horn falls upon my ears. I am in complete agreement with Mr. Hawke that, if an interval signal is really necessary, then more appropriate music could be played.

Kilburn, London, N.W.6 **R. D. QUINN**

May-day Mirage

A rather unusual and conspicuous mirage was observed on May 1, 1949, from 14.00—16.30 B.S.T. over the Wash from Hunstanton beach.

The weather was clear with a brilliant deep blue sky, light bluish-green just on the horizon. Visibility was very good (40 miles or more) with a light N. to NE. wind. The sea was out, leaving behind a wet sandy beach which towards the south west was shining with silverish-blue reflected sunlight. To the north-west was shallow sea water, warmed by sun, of a dark dirty colour caused by sand, sea-growths and shells below the surface.

The phenomenon occurred between N. and NE. at a distance of about 1300—1500 yds. from us. It was also observed by Mr. A. E. Wallis who first drew my attention to it. A dark smooth sheet of water changed sharply at this distance to a bright silver-blue, spreading towards the open sea and merging with the sky, no horizon line being discernable in this direction. The display was mainly over the sea since the beach narrowed in that direction. Most probably it was a distant wide sector of the beach with objects and people on it re-reflected. We could distinctly see little human figures walking to and fro far out on the sea but the "permanent" objects changed position with time very little and this was probably only due to the motion of the sun. A group of beach huts was visible on the right for about 20 minutes, one of them of yellowish colour. With a decrease of the angle of view, i.e. by bending down to about 3 feet, the bright surface spread a little towards us, the objects and the illusive walkers faded and then completely vanished. The other people present on the beach over which we watched the mirage, did not disappear. With an increase of the angle of view the objects reappeared and the people again walked on the sea. By standing on small rocks (3—4 feet) it all became more clearly defined.

The tide coming in developed small waves like cirro-cumulus cloud on the shiny surface of this phenomenon.

R.A.F., Coltishall, Norfolk S. SZCZYRBAK

The Rhythmic Year

Not to be prophesied with certainty
Nor timed and dated, like the earth's sea-tide,
Our Island-seasons' special quality,
—Diversified.

Free in the rhythmic ballet of the year
The months uniquely dance, each in her place,
And through the changing annual pattern veer
In balanced grace.

And should exaggerated motion cause
A dancer in her pose to overlean,
Extreme in mirrored opposite restores
The rhythmic mean.

The rhythmic mean ! For should a dancer change
Her role to ape another's, there must be
Some other month whose movement will be strange
In harmony.

So, if we cannot forecast, we may guess,
As guessed old shepherds on their lonely hills,
—If March comes bright with May's own loveliness
Beware June's chills !

G. M. HAWKSLEY

INSTRUMENTS, BOOKS, ETC., WANTED OR FOR SALE.

WANTED

The Royal Meteorological Society is receiving many requests for back numbers of the *Quarterly Journal*, in particular those published during the post-war years. Stocks of all the following issues are now so low that the demand for them cannot be fully met.

1879–1914	Vols. 5–40 (all numbers).	1936	Vol. 62, No. 263.
1917	Vol. 43, No. 181 and 182.	1937	Vol. 63, Nos. 268, 271 and 272.
1920	Vol. 46, No. 194.	1938	Vol. 64, Nos. 273–277.
1922	Vol. 48, No. 201.	1939	Vol. 65, Nos. 278, 280 and 281.
1926	Vol. 52, No. 217.	1940	Vol. 66, No. 283.
1927	Vol. 53, Nos. 221 and 223.	1941	Vol. 67, No. 288.
1928	Vol. 54, Nos. 225, 226 and 227.	1943	Vol. 69, No. 301.
1929	Vol. 55, No. 229.	1944	Vol. 70, Nos. 303–305.
1934	Vol. 60, No. 253.	1948	Vol. 74, No. 320.
1935	Vol. 61, No. 259.		

The Council would be grateful if Members who can spare their copies of any of the above numbers would kindly return them to the Office. For all such copies received in good condition, payment at half the published price is offered, plus postal expenses. The issues in chief demand are those from 1943 onwards.

FOR SALE

Short & Mason micro-barograph. N.P.L. Certificate, and set of charts; very good condition; two years' use—£22.

S. & M. min. thermometer, £2; max. thermometer, £2.

S. & M. wet- and dry-bulb thermometer and wicks, £4; all in excellent condition.

S. & M. hygrodeik, as new, £6.

Manual of Meteorology (Shaw), 4 Vols.; latest edition; excellent condition; £6. RICHARDS, 6, Barnfield Crescent, Wellington, Salop.

One Recording Rain Gauge—"Hyetograph"; one 8-inch Snowdon type Rain Gauge.
Offers to:—GREENHOW, 26, St. Mark's Road, Windsor, Berks.

Errata

Weather, June 1949, pp. 174-175; the author of the book *Top of the Atmosphere* reviewed on these pages should read G. Grimminger *not* R. Grumminger as printed.

Ibid., p. 198; the 1st Prize winner of the Sir Mapier Shaw Competition was R. M. Glaister *not* R. M. Glaisher.


A "Record" worth Having
This Radiosonde was developed by Salford Electrical Instruments Ltd., in conjunction with the Met Office, and is being manufactured in large quantities. It comprises a radio transmitter which is modulated alternatively by an audio-frequency which depends upon the temperature pressure and humidity. The met elements have been chosen for their stability and cyclicity, and its results are better than any similarly priced instrument in the world
Where it is necessary to use a really accurate and reliable Radiosonde, capable of simple interpretation of results, the "Salford" Radiosonde cannot be improved upon The instruments we offer are individually calibrated, ensuring that the potential accuracy is always attainable.
Production is on a large scale, and this Company is always in a position to give a quick delivery for export, in addition to those which are being supplied in large quantities to the Meteorological Office. We shall be pleased to supply full technical data on request.
Salford Electrical Instruments Ltd.
PEEL WORKS, SILK STREET, SALFORD

AUGUST 1949

WEATHER

Vol. IV No. 8

CONTENTS

EDITORIAL

The parliamentary report in the *Times* of 28 April, 1949 quoted Mr. Arthur Henderson as saying " The general accuracy of weather forecasts has been 85—88% in the last few years, and a check of recent months has shown that the accuracy has improved to 90% for forecasts of rain or no rain in the London area". The *Picture Post* of 5 February 1949 stated " For over 20 years the Bartletts have maintained a standard of accuracy that ranges between 80 and 90% on all forecasts" (See also p. 251).

After wondering why we bother to run an elaborate Meteorological Office when a much smaller organization will do just as well, the public probably felt inclined to distrust both statements. Many people would unconsciously associate the accuracy values with school examinations in which 90% is a very good mark, but they could with equal justification think of an utterly damning statement such as "At last night's performance the pianist got 90% of the notes right". In fact, 85–90% for the official forecast can only mean what we know already: " Not particularly bad, but plenty of room for improvement".

Both the Meteorological Office and the Bartlett brothers should, of course, have indicated the method of arriving at their figures, for otherwise they are meaningless. Readers will remember that systematic tests of official forecasts show a small, hardly significant, improvement from 1936-46 and a very considerable improvement since 1912 (*Weather*, Feb. 1947, p. 44 and May 1947, p. 147, A. R. Meetham and J. S. Dines).

For a satisfactory comparison of different systems, something like a British Standard Specification would be needed, together with the full cooperation of the forecasters. It would have to be a *British* standard ; Londoners may not mind guessing wrong about their umbrellas once in five or ten times, but what sort of a rain forecaster would be only 90% right in a monsoon region or the Sahara desert ?

MET. MEN "DOWN UNDER"

By H. T. Ashton, B.Sc., A.Inst.P.

In the June, 1948, issue of *Weather*, Volume 3 No. 6, appeared a short account of projected expansion and development in the Australian Meteorological Service. One advance which has now been successfully in operation for a year is the staffing of sub-antarctic stations at Macquarie and Heard Islands. A posting to one of these stations means, in addition to hardship and the normal duties of a Met. man, the excitement and glamour of adventure. Special qualities of the pioneer or explorer are needed. He must be thoroughly fit physically to be able to bear discomforts and setbacks cheerfully, overcome difficulties, and pull his weight with the team. Not the least surprising feature in the staffing of these remote stations is that the only problem that arises is one of a surplus of volunteers ; all volunteers cannot be accepted, the problem is one of rejection. Yet this is how they fare :—

Macquarie Island, Christmas, 1948—

> " Although overcast, Christmas Day calm, very mild, temperature 43°. Streamers, grasses, leaves decorated mess and gaily-printed meteorological lanterns shed soft light . . . And what cheer the menu . . . season indeed one of goodwill."—Martin.

Heard Island, Christmas, 1948—

> " Savoury smells remind us Christmas at hand . . . All except two will be in camp for Christmas. Arthur Scholes and myself will spend it camping out on the NE. tip of Cape Laurens and for Christmas dinner will have half a tin of bully beef, half a dozen hard biscuits . . . ."—Gotley.

Macquarie Island, 22/9/48—

> " Weather Sunday worst experienced since arrival Island. Barometer fell inch twelve hours, then rose phenomenal rate inch nine hours . . . Sand, pebbles, debris streaming Eastward all day. . . Late afternoon fierce squall hit camp. Impact almost solid and distant-recording anemometer recorder swung hard to seventy-knot limit before instrument itself succumbed. . . Same time balloon hut structure weakened . . . hurried salvage proceeding when diesel hut suddenly collapsed. Roof last seen flying over camp hill. . . B. Monkhouse, R. Chadder spend Monday recovering odd pieces anemometer, rain gauge, etc., scattered about isthmus."—Martin.

Heard Island, 27/7/48—

> " Yesterday fourteenth July windiest period we have experienced. . . Wind gusts rose to 60 miles per hour, and during afternoon many heavy squalls reached 90. At onset of gale radiosonde released and information obtained up to 50,000 feet. At 6.30 p.m. gust 100 m.p.h. blew down one aerial . . . gusts over 90 quite common . . . Shortly before 9 p.m. wind dropped to 4 m.p.h., but within a few seconds had risen to 108 . . . eighteen hours of sustained gale."—Gotley.

Now what of the " stay-at-homes," the ordinary observers of the Commonwealth Meteorological Service ? We have no need to think of the tropical ex-centre of administration at Rabaul (well known because of its long occupation by the Japanese during the war) or the isolation of Willis Island (564 yards long, 150 yards wide, 27 feet high, 300 miles East of Cairns). The continent itself is large enough, and great tracts are desolate enough to stir the spirit of adventure. The network of meteorological stations over parts of the vast interior is extremely sparse. Pedal wireless, which, with the Flying Doctor Service, has become such a boon to the " Inland " in the last few decades, plays an important part in the weather reporting service in these areas. Some reports are received from cattle stations and other isolated centres. These are supplied by co-operative observers outside the Meteorological Service,

but there are still areas hundreds of miles square which have no reporting stations. The demands of aviation have, however, necessitated establishment of airfields and reporting stations staffed by trained meteorological observers in areas almost as effectively isolated from normal amenities of life as remote islands. The normal term of service in these locations is a three years' stretch. Today conditions are improving rapidly. Housing plans are maturing with gratifying speed, so that loneliness will soon be the only serious drawback to service in these places. But during the years following the cessation of hostilities life has not been a bed of roses for the men who have carried on the field service. Certain postings are not welcome, but those who are from the city man's point of view " condemned " to a term of outback, carry on with an unquenchable ability to see the lighter side of life.

At the Headquarters of the Meteorological Branch in Melbourne is a file " Living Conditions at Remote Stations". The most avid readers are trainees who have just learned their destinations after completing courses. Started with the definite object of tabulating conditions for the information of men proceeding to station and of enabling them to fit themselves to the best advantage, the file has become an unconscious tribute to observers compiled by themselves, and of course an invitation to write official communications in somewhat lighter vein than usual :—

Living Conditions at Daly Waters, Northern Territory, April 1947—

Location : Aerodrome situated on North-South road 315 miles south of Darwin. Settlement consists of aerodrome, post office and hotel, spaced equally over a distance of one mile.

Population : 20 white persons and 40 natives. Nearest store and police station at Newcastle Waters, 78 miles to South. Nearest doctor, hospital and school at Katherine, 140 miles to North.

Living Conditions : . . . No charge is made for accommodation as the quarters have been declared untenable owing to the ravages of white ants.

Sport : *Nil.* Only game worth shooting is wild turkey which can be found on the 'drome. (Shooting of these is prohibited.)

Social Life : *Nil.* Nearest picture show Tennants Creek. Nearest dance Katherine.

Living Conditions at Oodnadatta, S.A. December 1946—

Location : Situated near the Neale River, which rarely has any water in it, about 300 miles South of Alice Springs. Population 90 (black and white).

'Drome : A large stony plain of 5 square miles with made runways which are the only asphalt paths in the district.

Social and Entertainment : Practically *nil.* One race meeting annually. Nearest pictures Alice Springs (300 miles).

Hobbies : *Nil.* Even gardening is out owing to the nature of the ground and the water supply.

Living Conditions at Karumba, Queensland. September 1946—

Location : Station situated on the bank of the Norman River, 3 miles from the mouth and 50 miles from Normanton (a ramshackle plains town fitted with three hotels, two stores, post office, police station, hospital, and with total population 300, not including natives).

Greatest Menace to Comfort : Sandflies. As these are present in greatest numbers when a North breeze assists them from the river, their onslaughts can be forecast by Met. personnel, but prior knowledge of their arrival does not reduce their activities.

Sport—outdoor : Hiking, excellent shooting, good fishing. No swimming—unpopular on account of sharks and crocodiles.

General : The cook is the unrecognized dictator, but fortunately is no tyrant. The station possesses a dog and a cat, conferring one touch of domesticity.

STRUCTURE AND DYNAMICS OF THE THUNDERSTORM

PART II

By HORACE R. BYERS, Sc.D.

University of Chicago

In Part I of this article, last month, an account was given of the Thunderstorm Project; and of the discovery that the usual large thunderstorm contains areas of stormy turbulence each surrounded by a narrow belt of smooth but cloud-filled air. Thus the structure is cellular. The life cycle of the cell naturally divides itself into three stages : the *cumulus stage*, the *mature stage*, and the *dissipating stage*.

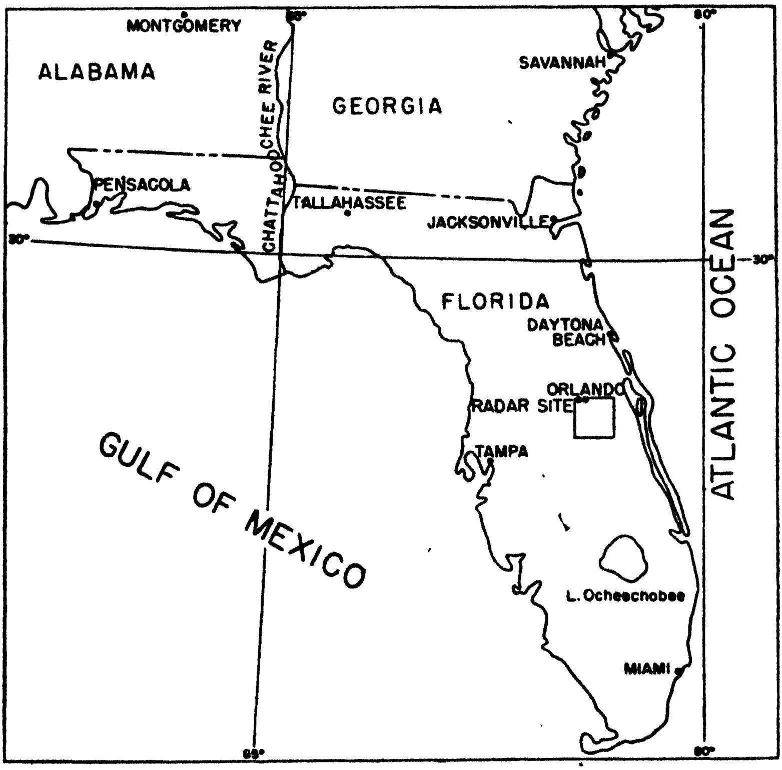


Fig. 1. Map of Florida and adjacent regions showing the location of the 1946 observation area near Orlando.

CUMULUS STAGE

The first stage of the thunderstorm cell is the cumulus cloud, although only a small number of cumuli actually build into thunderstorm cells. During this stage two or three cumulus clouds may grow together into one cell whose diameter may be between one mile and five miles and whose top usually does not initially exceed 15,000 feet.

The most important structural feature of the cumulus stage is the updraft

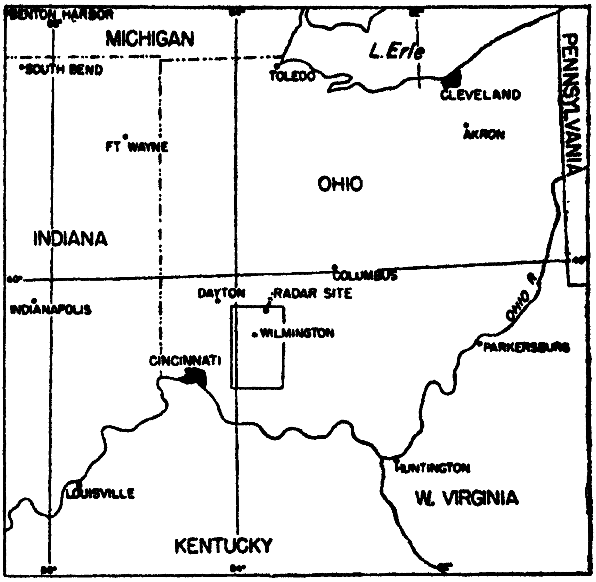


Fig. 2. Map of Ohio and adjacent regions showing the location of the 1947 observation area near Wilmington.

prevailing throughout the entire cell, balanced by slow settling in the environment. As might be expected, the temperatures in appreciable updrafts are higher than in the environment at corresponding levels. The air motion in a vertical cross section through the cell in the cumulus stage is shown in Fig. 3. The general updraft varies from only a few feet per second in small and weak cells and cells in earlier stages of development, to almost 100 feet per second in large well-developed cells.

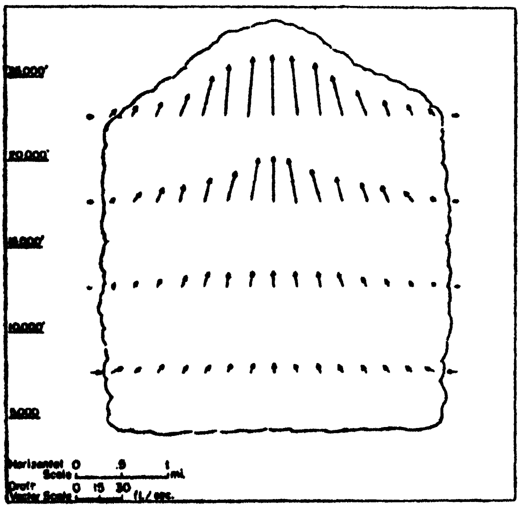


Fig. 3. Distribution of vertical air currents in the cumulus stage.

In accordance with well-known precipitation theories, raindrop coalescence occurs when the cloud top has extended some distance above the freezing level. When the accumulation of water exceeds in amount and in drop size that which can be supported by the updraft, the drops begin to fall through the weaker portions of the updraft and the cell passes into the mature stage of development.

MATURE STAGE

In the mature stage the cell contains in the lower levels a pronounced downdraft adjacent to the updraft. The downdraft reaches downward from approximately 25,000 feet and throughout the cell above that height the updraft continues. The rain at the surface is associated mainly with the downdraft portion of the cell. The structure is shown in Fig. 4.

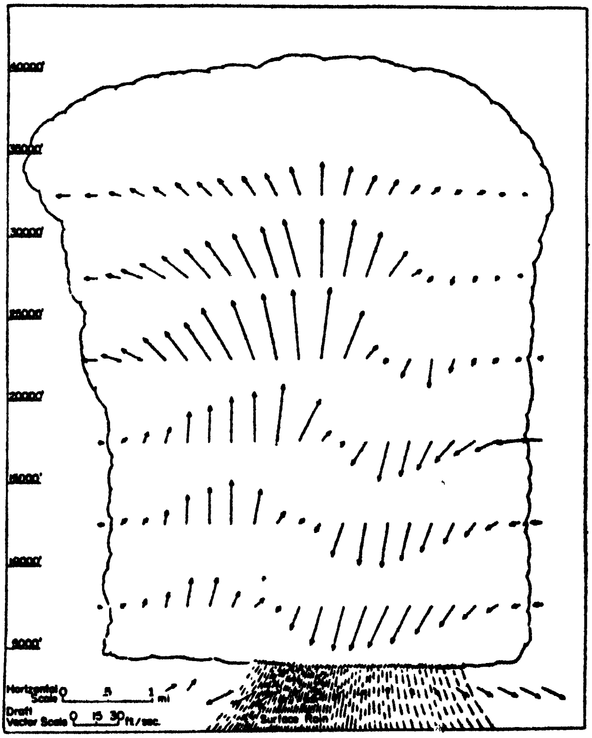


Fig. 4. The mature stage, showing rain and downdraft

The downdraft results primarily from the presence of falling rain in an area of former updraft. The raindrops become so large and numerous that they exert a frictional drag on the air sufficient to change an updraft into a downdraft.

At this point in the description of the thunderstorm cell it is necessary to insert a few remarks concerning the thermodynamic processes. Classical treatments consider the ascending air from the point of view of the so-called " parcel method ". In this process the rising air is regarded as changing its temperature with the expansion and water-vapour condensation due to pressure decrease in

such a way that it is neither affected by nor produces effects upon the environment air. In doing so, its temperature decrease follows the so-called wet-adiabatic rate. Laboratory experience and our atmospheric measurements show that the ascending air of the cumulus cloud behaves in much the same way as a vertical jet stream in the laboratory in that it frictionally entrains part of the surrounding air. This means that air of less than saturation humidity comes into the cloud and mixes with the cloud air. In the active cumulus, there is enough liquid water being carried in the updraft to preserve saturation, in the face of intrusion of relatively dry air, without completely evaporating. That which evaporates in the mixing process loses part of the heat acquired in the cloud condensation process. As a consequence, the ascending air cools at a rate faster than the wet adiabatic and at any point is very near the temperature of the environment.

When the frictional drag of the great mass of large raindrops finally changes the updraft to a downdraft, the descent involves increasing temperature at the adiabatic rate, so the rate of warming in descent is less rapid than the cooling in the ascent, as shown in Fig. 5. Mixing of outside air would tend to make the downdraft even colder, because of evaporation of raindrops. Thus the downdraft becomes a falling current of cold air which spreads out laterally as it strikes the ground.

All of the striking phenomena observed at the ground in thunderstorms are directly associated with the downdraft. Among these are the downpour of rain, the temperature discontinuity, the squall front or " first gust ", the barograph jump or " thunderstorm high ", the humidity dip and, to a considerable extent, the cloud-to-ground lightning discharge.

Either from the first gust of wind that reaches out from the downdraft area or from air-mass identification in terms of temperature, the outflow of the downdraft air can be traced with precision through the Florida and Ohio micro-networks. Results show that the cold air spreads almost equally outward in all directions when there is no extraneous wind, but is carried downward in a strongly diverging flow when the prevailing unperturbed winds are appreciable. A discontinuity is formed between the outflow air and the surrounding warm air. Although originally formed in the rainy portion of the cell, the downdraft air soon outruns the rain area and its arrival is felt at places several miles from the precipitating cell. The first blast of downdraft air experienced at a station is the strongest, but as long as the outflow continues, strong, gusty winds are observed. The strength of the first and succeeding gusts is less the farther the air has spread, being the strongest near where the downdraft first reaches the ground in the early mature stage. There, as well as elsewhere, the wind speed and gustiness decrease with time as the spreading continues, except in those cases where a new adjacent cell reaches the mature or rain-producing stage.

Computations of the outflow, made from a study of the wind field as measured in the surface micro-network, show very pronounced patterns of horizontal divergence centres with the maximum values in the heaviest rain at the point where the downdraft appears to be concentrated. The simultaneous releases of rawinsonde and rawin balloons at several points around individual storms

having mature cells indicated outflow from the ground up to heights varying between 2,000 and 5,000 feet, with the inflow above that height. This measured inflow provides a verification of the idea of entrainment of environment air into the vertically moving air of the cloud. In the later mature stage, and in the dissipating stage, outflow was measured by the balloons at heights above about 25,000 feet, corresponding to the anvil portion of the cloud.

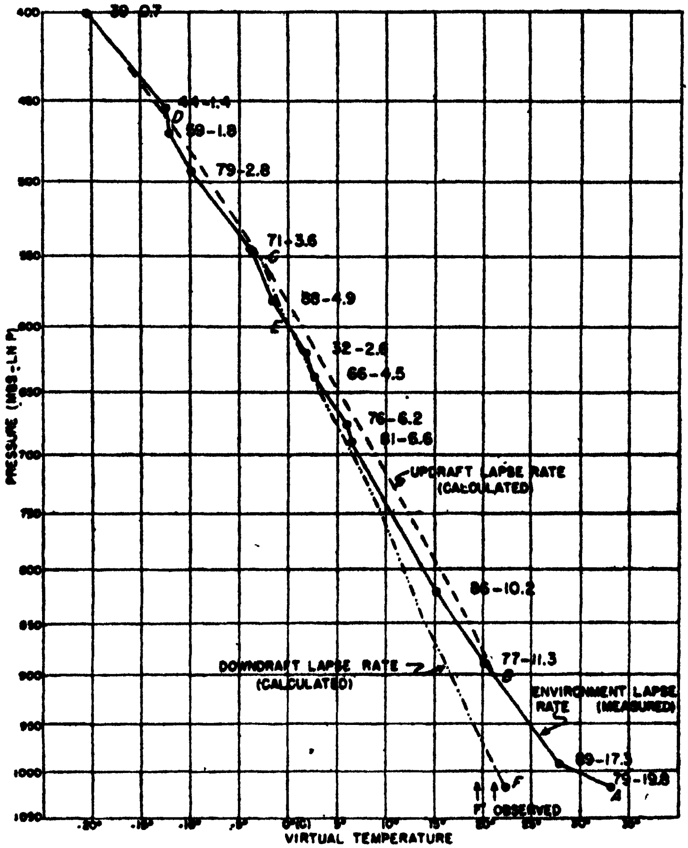
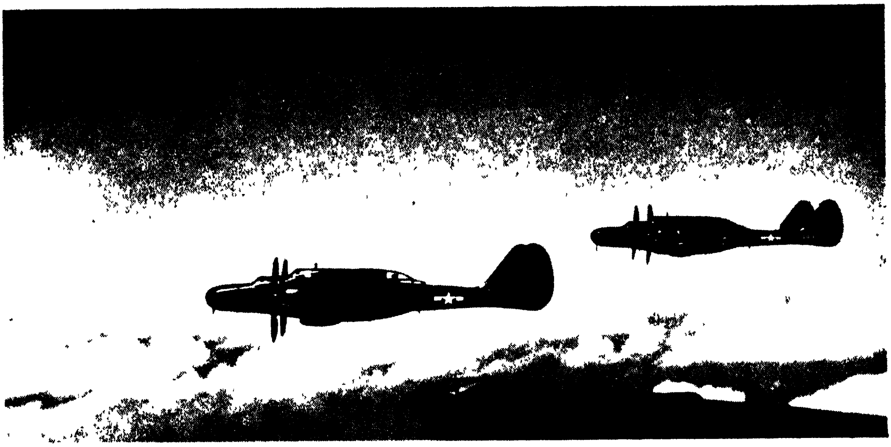


Fig. 5. Environment lapse rate, updraft lapse rate and downdraft lapse rate represented on an adiabatic chart. The wet adiabatic rate, which is not shown, would be represented by a curve running from B well to the right of the other curves. A 100 per cent mixing with the environment in 400 mb. of lifting is assumed. The virtual temperature is used in place of the actual temperature in order to allow for the effect of the water vapour on the density.

In general, one may say that heretofore meteorologists, in emphasizing the thunderstorm updraft, have been barking up the wrong tree. The downdraft is by far the most striking feature, at least in the levels at or near the ground. The inflow winds that feed the updraft are mere zephyrs at the ground, while the outflow from the downdraft, produces winds of destructive force. Other striking changes such as the temperature drop and the pressure nose or " thunderstorm high " go with the downdraft.

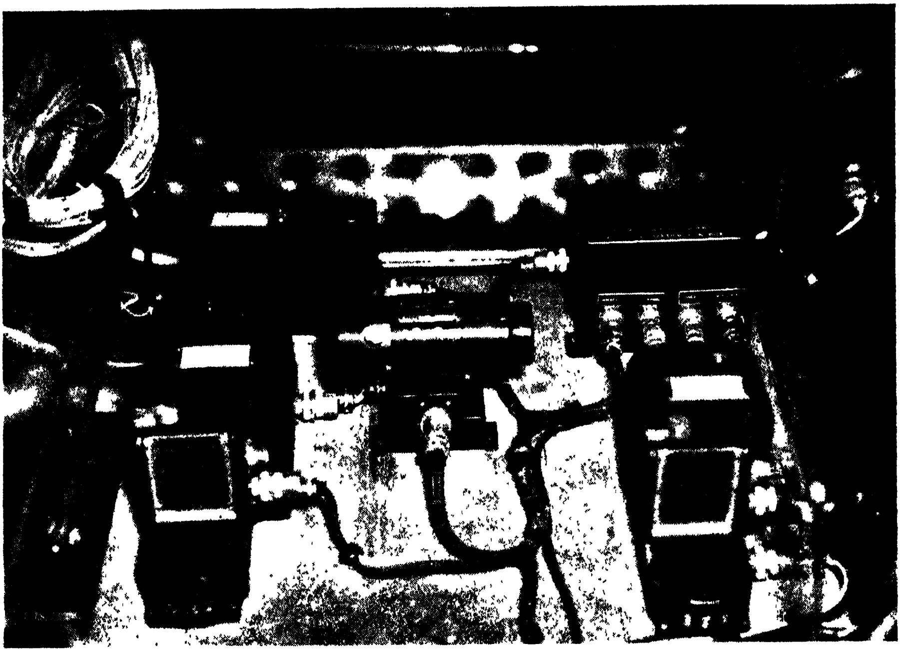
Also, it is evident that as a thermodynamic engine the thunderstorm does work both through the updraft that is warmer than the environment and



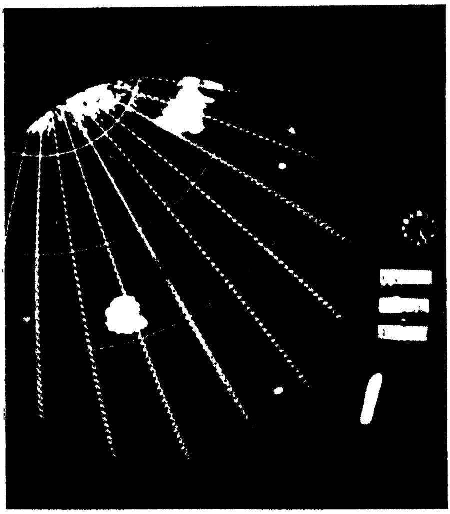
Formation of P-61 airplanes above a layer of broken stratocumulus

Refuelling the P-61's after a flight through a thunderstorm

PLATE I

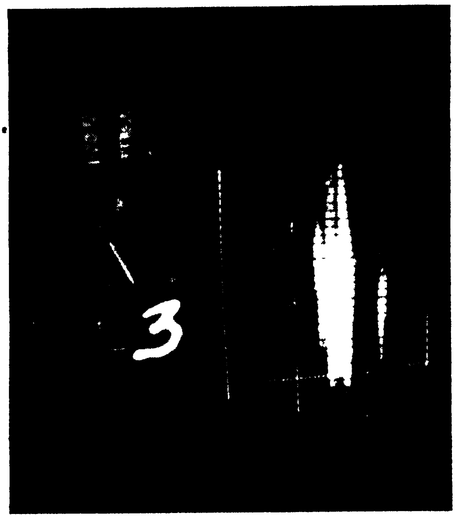


Photorecording Instruments for Measuring Turbulence and Drafts.
Furnished to the project by the National Advisory Committee for Aeronautics



Reproduction of a Photograph of the Thunderstorm Echo (bright areas) as shown on a PPI 'Scope.

The radiating lines indicate Azimuth from north relative to the radar site: the concentric arcs are 10-mile range markers



Reproduction of a Photograph of the Thunderstorm Echo (bright areas) as shown on the RHI 'Scope

Horizontal lines on the 'Scope indicate height in thousands of feet; the vertical lines are 10-mile range markers

through the downdraft that is colder than the environment. Temperatures measured from the airplanes amply demonstrate these differences in temperature and in fact show that the stronger the draft the greater the temperature difference, in the sense indicated.

DISSIPATING STAGE

When the downdraft has spread across the lower levels of the cell to the extent that the updraft area becomes of secondary importance, the cell passes into the dissipating stage. As the process continues, the entire lower part of the cell has downdrafts while in the higher levels there are negligible vertical

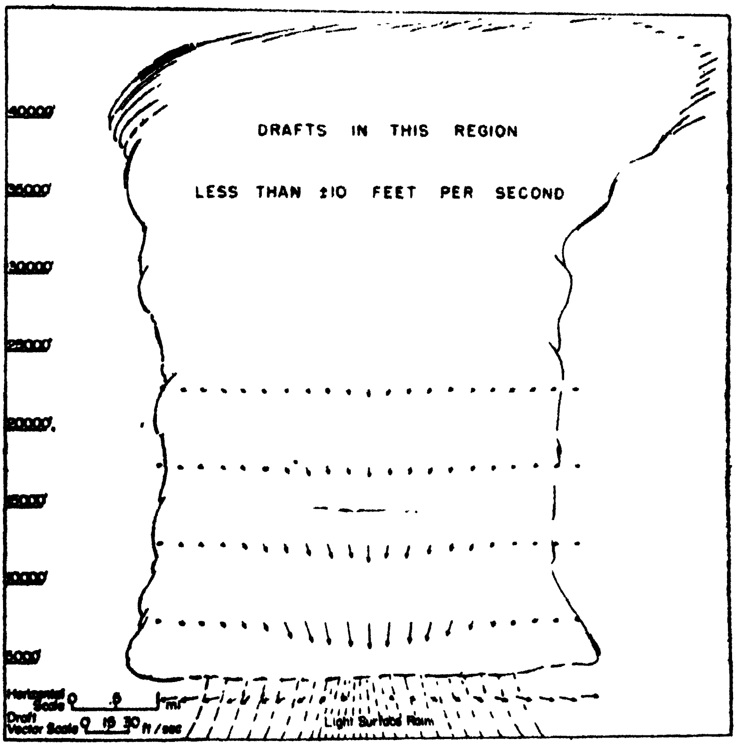


Fig. 6. The dissipating stage, showing light rain and downdrafts in the entire lower part of the cell.

motions (Fig. 6). Slight downdrafts exist as long as light rain continues, although the entraining of environment air at this stage must be a contributing factor to drying and eventually obliterating the cloud at lower levels. The time-lapse pictures taken by the project indicate that clouds first dissipate in the lower levels.

By the time the rain has stopped, large-scale vertical motion has died away and cell boundaries have become very indistinct. The storm usually ends up as a dissipating layer of altostratus.

THE OUTFLOW AND NEW CELLS

One of the effects of the outflowing cold air which was immediately recognized and which was also known to previous investigators, was the action of the pseudo-cold-front in " triggering " the growth of new cells. It was found that

the greatest probability for new cell development is in the region between two cells not more than three miles apart, where two cold outflows meet to squeeze the warm air upward. Downwind three miles or less from an existing cell is another place of importance for cell development.

In some cases the new cells developed before there had been time for the cold-air outflow to make its influence felt. It seemed that frequently there was a tendency for cells to grow in clusters almost simultaneously. Some more general features of the dynamics of the air in the vicinity must be a contributing cause in these cases.

FLIGHTS THROUGH THUNDERSTORMS

During the two seasons of measurements, the Air Force pilots made a total of 1,363 penetrations through thunderstorms at various altitudes without accident. An effort was made to perform these flights through the most vigorous thunderstorms that could be found in the area of operations. The analysis of these flights furnishes valuable information concerning hazards in thunderstorms.

Turbulence was found to be greatest at the middle and upper altitudes flown, that is, from 10,000 feet upward, with the greatest values appearing between 15,000 and 20,000 feet. The least turbulence was found in the lower layers. Updrafts were strongest in the higher levels as were also, to some extent, the downdrafts. The lightning and hail hazards were found to be greatest around 15,000 feet. In general, the worst conditions were encountered at the altitudes at which modern airplanes with supercharged cabins are most frequently flown. The use of airborne radar to avoid thunderstorm centres of turbulence, particularly at these upper levels, was indicated to be desirable. With 10-cm radar, it was found that the turbulence outside the cloud echoes was negligible compared with that inside. The possibility of developing radar to the extent that the smooth areas between the cells can be followed should lead to a satisfactory solution of the thunderstorm flying problem at all levels.

EVERYBODY'S WEATHER BOOK

235 pages, 16 plates — By Reginald M. Lester
Sampson Low, Marston & Co. Ltd. — London, 1948. 15s. 0d.

This recent addition to the literature of popular meteorology should be read by everybody who aspires to write an elementary scientific book ; it might be described as a textbook example of how not to do it. "What is the scientific explanation of the rainbow colours ? It appears in the opposite point of the compass to the sun, and is caused by the sun's reflection of a cloud of raindrops there. The sunlight passes through these raindrops, and as it does so it is broken up into a number of components, each one corresponding to one of the many colours." The book is full of such confused attempts to remove "the confusion in the lay mind". Readers will also learn that the surface temperature of the sun is "70,000,000 degrees Fahrenheit" (p. 169), "6,000 degrees Centigrade" (p. 198), and "only about 12,000 degrees" (p. 201) ; they will discover that absolute humidity is measured in "grams per cubic foot" (p. 106), that many reliable observers have heard the aurora in mid-summer (p 132), and that after midsummer day the sea is warmer than the air (p. 194).

Much material is repeated from the author's war-time book, *Weather Prediction*, and there seems little justification for this new version. O. M. A.

SIGNPOST TO THE WEATHER

120 pages, 63 figures — By D. & K. Bartlett
Edward Stanford Ltd. — London 1949. 3s. 6d.

Readers of the *Evening Standard* each Monday must wonder how the Bartlett brothers produce their forecast of the week's weather—even if they do not consider it very precise or accurate ! The year is divided into 48 "weeks" of 5 to 8 days, for each of which a Bartlett Weather Expectation is laid down, based on 50-year records of seasonal climatic changes and superposed fluctuations lasting ½ to 2 weeks. If the present weather fits the Expectation, the forecast continues in accordance with the Expectation for the coming week ; if a particular spell of weather seems to be earlier or later than the Expectation, the forecast is altered on the suppositions that (*a*) fine spells tend to be prolonged and (*b*) the weather will readjust itself back to the Expectations within two or three weeks. As the authors say, the method is not infallible. It does not forecast actual temperatures or rainfalls, but its effectiveness might be tested by some system of scoring marks for information of practical value.

Helped by straightforward, intelligible style and illustrations, the writers make incredibly light work of meteorology. Unfortunately, simplifications of this sort are at best only half true, and half-truths can be more harmful than lies As the introduction states, the book is not for a person who knows, but for those who are puzzled. By all means buy it for your friends if they are puzzled but be prepared to answer a lot of supplementary questions.

A. R. M.

ROYAL METEOROLOGICAL SOCIETY NEWS

When the Royal Meteorological Society visited the Royal Aircraft Establishment, Farnborough. on Wednesday, July 13, thundery weather was about, but the only " precipitation " of any consequence was the terrifying shower of sparks in which Mr. Armstrong made a number of perfect flash welds. After a welcome and address by the Director, Dr. Perring, the party of 76 saw a demonstration of the pilot-ejection rig and spent the rest of the morning in the Structures Laboratory and the Metallurgy Department

The canteen provided an excellent seasonable lunch, and the party walked over to the airfield, to enjoy the breeze and inspect many kinds of military aircraft, and the magnificent control tower which, until recently, had a greater flow of aircraft to handle than anywhere in the Kingdom It had not occurred to many of the party that R.A.E pilots employed on research and trials are often too busy to navigate, so their aircraft are frequently fixed by radar and plotted on a large board ; they can be guided home by R/T from a distance of at least 100 miles.

For the more scientifically minded, the high spot of the day was the half-hour spent in the prefabricated hut of the Meteorological Research Flight, evidently the best the establishment could offer in the way of a small back room. Here Dr Frith demonstrated the ways now being used for measuring water in the atmosphere. Three instruments for measuring liquid water and size of drop showed that for making measurements in clouds an ordinary rain gauge is hardly the thing. With a neat arrangement of two electrical resistance thermometers in air of fluctuating temperature, Mr Grant demonstrated the danger of employing a thermometer of 7 seconds time-lag in a fast-moving aircraft. The Dobson - Brewer Frost Point Hygrometer was there in three different forms, and Mr. Goody in another room showed what is being done to measure still smaller amounts of water vapour (and nitrous oxide,

carbon dioxide and other gases) spectrographically with infra-red light from the sun. He had a magic mirror which could find the sun and, however much the aircraft might oscillate, keep its image on a fixed spot.

With a home-made projection microscope, Mr. Shellard demonstrated the growth and shrinking of a condensation nucleus in air of varying humidity. It was easy to see how variations in the size of nuclei could affect visibility.

Teatime came much too swiftly and the party went home to find whether the approaching front—which they had seen on the charts in the control tower—could be energetic enough to water their gardens.

CANADIAN BRANCH

On February 24, Mr. George Jacobson, of the Prefabricated Homes Company, gave an interesting talk on the difficulties of building suitable houses in the Arctic. House foundations are the biggest problem, for the effects of permanently frozen ground, or permafrost, as it is called, cannot be overcome directly by man and a passive approach is necessary. If piles are driven down through frozen silt or soil and a steel and concrete base then constructed, differential movements of the piles may fracture the foundations. On silt or soil a floating platform of concrete is best, but the site must be chosen carefully or water flowing underneath and then freezing may raise the whole building. The lecturer stressed that the conventional houses of temperate climates are not suitable for the Arctic. Light, hollow panels constructed on the same principle as an aircraft wing and easily erected on a skeleton frame, give a dwelling with excellent insulation and strong enough to resist storms.

On March 31, Mr. MacTaggart-Cowan made an informative report on the Annual Meeting of the American Meteorological Society, which he attended in New York in January of this year. The Symposium on Cloud Physics seemed to provoke most interest, cloud seeding and the inducement of artificial rain were discussed by several speakers, ranging from the optimistic Dr. Irving Langmuir to the cautious Dr. Ross Gunn and collaborators. Mr. T. C. Bell told of the artificial-rain experiments in Australia which have shown that substantial amounts of rain can be produced, but only in special cases. This seemed to be the general impression gained from the whole discussion, though there was considerable divergence of opinion. In the Symposium on the Upper Atmosphere the instruments for use on large rockets and the U.S. Navy's new "Sky Hook" balloons* for constant-level flights were described among other things. In the Thunderstorm Symposium a report on the projects in Florida and Ohio was given†. It appears that the area of maximum turbulence in a thunder cloud is about 10,000 ft below its greatest height and associated with its greatest water concentration. The "downdrafts" below thunderstorms are associated with the rain areas. In the Symposium on the Dynamics of the Atmosphere, Messrs. Namias and Clapp put forward a new theory for the formation of a "jet stream," suggesting that it is the confluence of cold and warm currents of different origins caused by waves in the westerlies which are out of phase in high and low latitudes. Messrs. Haurwitz and Spilhaus also reported the detection of considerable oscillations in the stratosphere and troposphere using constant-level balloons; the period of these oscillations was about 10 minutes and vertical velocities of about 1,000 ft per minute were associated with them.

Mr. Halbert then described the high speed facsimile equipment used to transmit meteorological charts by short-wave radio from the Chicago City forecast office to the Municipal Airport 14 miles away.

* See *Weather*, April 1949, p. 109.

† See Professor Byers' article, p. 244.

WEATHER AND NERVES

By A. J. Whiten

In the Editorial of *Weather*, February 1948, a suggestion appeared that amateur meteorologists might find useful employment in " the study of the effect of weather and climatic conditions on human ailments". I had already taken the first steps in this direction by a study of the reactions of victims of neuritis and other forms of rheumatism, and a panel of over 100 sufferers has since been enrolled, who send in, about every three months, records giving dates and approximate times when they experienced increased pain or relief. These observations are recorded on file-cards, local weather conditions of a very comprehensive nature being extracted from the *Daily Weather Report* and recorded thereon.

The intention is, when a sufficiently large number of cards have been filed, to compare the frequency of the coincidence of changes in the condition of patients with those in atmospheric conditions, draw any reasonable conclusions, and present the results to the medical profession as a possible starting point for further research into this aspect of the nature of rheumatic disabilities.

The usual routine in clinical circles would presumably be to examine the condition of the patients when the environment changes, and this could only be done by the medical profession. The present intention is rather to examine the atmospheric conditions which coincide with marked changes in the conditions of a number of patients ; and with a little necessary medical advice, this can best be done by the application of some small knowledge of the atmosphere and its nature.

One of the most formidable difficulties is purely medical, namely the effects of extraneous causes irrespective of weather. It is well known that a sufferer from neuritis can " worry " himself into a bout of pain, and that overwork of affected limbs will cause trouble. Over-indulgence, dietary indiscretions, and a host of other often untraceable causes will also extract their retribution. The start, finish, or changes in the course of treatment will change the nature of a record considerably. Any method of meeting this difficulty has to be as simple as possible. The easiest way is to arrange a " cancelling-out " of these effects by noting changes for better as well as for worse. For this purpose file-cards were printed in red and black, red cards being used for recording relief, black for increase of pain. Every time a black card is filed on account of some such extraneous cause, it will be followed in due course by a red one. This, of course, results in a bulking of the sample, which must have the effect of blurring any connections which may become apparent, so it is not possible to prove any strict relationships ; it is very doubtful whether any exist. But it should be possible to bring out some pronounced broad trends, which may be valuable as hints to the most likely direction for future research of a more specialized nature by professional workers.

Having done all that was possible to secure the necessary publicity, and explained to all what was required, there remained no more to be done except to await results.

Then followed months of routine grind, recording observations, extracting weather data from the *D.W.R.* and filing cards in drawers until such time as they could be used. Once this routine became a habit, the rate of extraction of data from the *D.W.R.* increased about three-fold, and it was just possible to keep pace with the incoming records as the number of observers increased. But at the end of 1948 there came a rather severe blow to this routine. The new International Codes were introduced into the *D.W.R.*! It promised to be a formidable task, working to two different routines while handling records from both 1948 and 1949. It was a prospect hardly to be contemplated by a single-handed investigator, and was ultimately funked completely. It was decided to do no more than record dates and times of observations in 1949 until all 1948 cards had been completed.

As the weeks went by, and the number of 1948 observations became fewer, this work took less time. By April there was much time to wonder: "Is this getting anywhere? Should the method of procedure be overhauled?" It was a good opportunity to tackle these nagging worries and to make a preliminary check-up on one or two points.

So the cards were all arranged, some 4,400 of them, in chronological order, the number of cards for each day being counted. Even then it was no straightforward matter to determine the "best" and "worst" days of the year without reflecting the rate of increase in the number of observers. The method adopted was roughly that employed by Buchan to determine his famous "spells." The daily values were plotted on squared paper, outstanding departures were noted, and seven "bad" and ten "good" days stood revealed.

RESULTS

Now came the critical stage, when it would be seen whether any positive results were to be obtained. A comparison of the two classes of days with the *D.W.R.* gave all the encouragement that could be desired. *All* the seven bad days occurred when low pressure was approaching either the west of Ireland, or the north of Scotland. When it is considered that during 1948 there were no observers in either Scotland or Ireland, this is quite an eloquent picture.

Reference to daily rainfall brought out very clearly the much-debated fact that rheumatic subjects *do* feel a pre-warning of coming rain. On five of the seven occasions there was no significant rain either on the day under notice or on the previous day, but heavy rain followed within thirty-six hours. On one occasion there was very little rain, and this fell on the next day. The seventh case came during a spell of heavy rain, which occurred on all three days.

Nine out of the ten "good" days came when high pressure covered the district affected—in eight cases the whole country was under high pressure,

on the ninth high pressure, centred over the English Channel, covered the whole of the south and midlands, which included the location of over 80 per cent of the observers, so this may be fairly said to fall into line with the other eight. The tenth case, the "proof by exception," occurred at the end of a spell of low pressure, but the barometer rose sharply that night and continued to rise for two days, thereafter remaining high for some time. Though I should hesitate to suggest that there may have been pre-knowledge of anti-cyclonic conditions, this was the only case out of ten, and may be reasonably written off as being more or less coincidental, subject to the findings at final analysis later on.

The conclusion from all this is that, when the final analysis is undertaken, the question of pressure gradient will probably be worth very detailed examination.

DEWPOINT

So much for the prospect of useful results. There remained the question of the suitability of the method of recording data. To test this it was decided to try a preliminary analysis of data in hand concerning dewpoint, so the cards were re-sorted, and a count was made of the number of black and red cards showing dewpoint at each degree from 12°F to 68°F at the last observation before the time of the change in the patients' condition. A frequency diagram of the black and red values was plotted, and two very instructive curves were produced, though at first sight they appeared to present a queer problem. *Both* black and red curves, though somewhat ragged, showed a very pronounced rise with an increase in dewpoint. When plotted from overlapping five-point means this characteristic was very clearly brought out. The rise, in both cases, was especially pronounced in the region of the freezing-point; thence they both flattened out, rising again steeply between 45°F and 60°F. Above this value the number of observations was insufficient to be significant.

This apparent contradiction is probably easily explained. A high dew-point usually occurs with a high temperature, and it must be borne in mind that the observations come from people suffering from many varieties of neuritis and rheumatism. This may explain why many sufferers complain bitterly of hot weather. It is suggested that they feel the effect, not of the high air temperature, but of the high dewpoint that accompanies it. Others, benefitting by the warmth, report "better". It is much too early to go further into this apparent anomaly, as many more observations from a larger number of sufferers are required.

A last analysis was made to determine any possible connections between pain and change of dewpoint. This was done on the same lines as the dew-point enquiry, and produced a couple of very uninformative curves. Average values were taken over rising and falling dewpoints; these were respectively 5·38 and 6·27. This small difference, taken in conjunction with the indeterminate nature of the curves, suggests that there is little or no connection.

FUTURE PLANS

The cards are now all returned to their record numbers, and fuller data regarding rainfall are being added to each card, consequent upon the determination of the probability that coming rain may be highly significant. When sufficient observations have been filed (by 1951, it is hoped), a very full analysis will be undertaken of such possibilities as relationship with pressure, temperature (maximum, minimum and range), relative humidity, wind direction and velocity, daily sunshine and cloud cover, fog, and atmospherics. Very particular attention will be given to the movements of pressure systems. In the meantime, a great deal of routine work remains to be done.

One of the biggest surprises has been the uniformly high standard of the records, which come from a very diverse assortment of people, including some with high academic qualifications, and others who can scarcely write a legible hand. The intelligibility and usefulness of the latter class of record is really astonishing. It has, nevertheless, been necessary to be always on the lookout for a carelessly-kept record. Every reminder that goes out bears a request that observations not noted at the time shall not be recorded from memory, but occasionally something occurs and it becomes obvious that a particular record is not fully dependable. For instance, when a patient wrote that the whole Easter holiday had been pain-free, and on the record card complains that Easter Monday was the worst day yet, there is only one conclusion to be drawn.

INSTRUMENTS, BOOKS, ETC., WANTED OR FOR SALE.

WANTED

The Royal Meteorological Society is receiving many requests for back numbers of the *Quarterly Journal*, in particular those published during the post-war years. Stocks of all the following issues are now so low that the demand for them cannot be fully met.

1875 Vol. 1, Nos. 1–8.
1876 Vol. 2, No. 12.
1877 Vol. 3, Nos. 20–24
1878 Vol. 4, Nos. 25–28.
1882 Vol 8, No. 41.
1884 Vol. 10, Nos. 49 and 50.
1889 Vol. 15, No. 72.
1890 Vol. 16, No. 73.
1892 Vol. 18, No. 83.
1897 Vol. 23, No. 104.
1900 Vol. 26, No. 113.
1901 Vol. 27, Nos. 117 and 118.
1902 Vol. 28, Nos. 121 and 122.
1903 Vol. 29, No. 126.
1905 Vol. 31, No. 133.
1906 Vol. 32, Nos. 138 and 139.
1907 Vol. 33, Nos. 141 and 142.
1912 Vol. 38, Nos. 161 and 162.
1917 Vol. 43, Nos. 181 and 182.
1920 Vol 46, No. 194.
1922 Vol. 48, No. 201.
1924 Vol. 50, No. 209.
1926 Vol. 52, No. 217.
1927 Vol. 53, Nos 221 and 223.
1928 Vol. 54, Nos. 225 and 226.
1929 Vol. 55, No. 229.
1935 Vol. 61, No. 259.
1936 Vol. 62, No. 263.
1937 Vol. 63, Nos. 268 and 271.
1938 Vol. 64, Nos. 273, 275 and 277.
1939 Vol. 65, Nos. 278–281.
1940 Vol. 66, Nos. 283 and 286.
1941 Vol. 67, No. 288.
1943 Vol. 69, Nos. 298 and 301.
1944 Vol. 70, Nos. 303–305.
1945 Vol. 71, Nos. 307 and 308.
1948 Vol. 74, No. 320.

Phenological Reports for 1942, 1943 and 1944 also required.

The Council would be grateful if Members who can spare their copies of any of the above numbers would kindly return them to the Office. For all such copies received in good condition, payment at half the published price is offered, plus postal expenses. The issues in chief demand are those from 1943 onwards.

THE WEATHER OF JULY 1949

MAINLY FINE, WARM AND DRY

For farmers and for those who were lucky enough to have a holiday, July was almost an ideal month. Apart from two short cold and cloudy spells around 7th and 18th the weather was remarkably fine. Sunshine, other than in the extreme west, was unusually plentiful and afternoon temperatures in the 80's were almost commonplace in the South. Rainfall figures were again generally low, to the dismay of gardeners and others affected by so many abnormally dry months.

The month began with an anticyclone moving slowly eastward over the British Isles, and for four days the weather was fine, with high maximum temperatures. Late on 4th a cold front passed eastward across England and a low developed on the front, over the Skagerrak the following day. A northerly current of air drawn from high latitudes, together with cloudy skies, brought progressively cooler weather that culminated in maximum temperatures of under 60° F on 7th in the South-East. A ridge from the Azores anticyclone extended its influence over the country on 8th and another warm and dry spell began, 90° F being reported at several places in England on 12th, which was the warmest day of the year over most of England and Wales. A depression off Spain on 12th moved slowly northward and later eastward up the Channel and was associated with outbreaks of thundery rain and some severe thunderstorms between 13th and 17th, over an inch falling at some places in the Midlands By 19th an anticyclone, then centred off the south-west of Ireland, ushered in the third and longest fine spell which lasted until 31st.

The great news of the escape of H.M.S. Amethyst from the Yangtze River is all the more striking, and providential, when it is realised that the river, which usually reaches its highest level in early autumn, has recently been in flood to an extent hardly precedented during this century ; furthermore, not within living memory has such a catastrophe come to Shanghai as that brought by the typhoon which struck the city on 25th.

The eastern United States have had to endure a heatwave since early June with scarcely a break ; during the last week of the month Government and municipal buildings were closed during the afternoons, when the temperature reached nearly 95° F. At Canberra, on the other hand, there was a fall of 12 in. of snow, the heaviest for 20 years.

	TEMPERATURE (°F.)				RAIN (mm.)*			SUNSHINE (hr.)		
	Long period Average		This month Extreme		Month	Diff. from Av.	Last 12 months	Month	Diff. from Av.	Last 12 months
	Max.	Min.	Max.	Min.						
Kew Obsy.	72·8	56·2	86	49	28	—35	454	253	+59	1679
Gorleston	67·9	55·4	81	47	17	—42	385	226	+15	1669
Birmingham	69·3	54·1	87	47	70	+11	708	194	+23	1447
Falmouth	66·2	55·0	†75	†48	47	—25	827	304	+87	1922
Valentia	63·7	54·7	79	47	59	—36	1287	154	— 3	1315
Aldergrove	64·9	51·5	79	41	43	—30	758	135	—16	1312
Holyhead	62·9	55·1	79	46	47	—19	689	232	+41	1644
Tynemouth	64·7	53·9	77	48	37	—24	473			
Renfrew	66·0	51·5	78	43	47	—24	1148	198	+49	1313
Aberdeen	64·2	49·6	75	43	64	—13	690	168	+11	1534
Stornoway	60·9	50·5	72	42	35	—38	1250	144	— 1	1247

* 25 mm. = 1 inch (approx.) † The Lizard C.R.B.

AIR MASSES OF THE SOUTHERN HEMISPHERE

By J. GENTILLI, D.Sc. (Venice)
University of Western Australia

PART I

PATTERN OF AIR CIRCULATION

The study of air masses in the southern hemisphere is made very difficult by the presence of large expanses of water, over which no continuous meteorological observations are possible. In fact, the most complete work on the climatology of the Pacific and Indian oceans, Schott's volume[1], largely relies on extrapolation for the higher latitudes of the southern hemisphere. The most thorough and factual work in this field, the atlas of climatic maps of the oceans published by the United States Weather Bureau[2], embodying more than five million observations, plainly leaves the higher latitudes blank.

Before proceeding to a brief outline of the air masses and their sources, it may be desirable to describe the general pattern of air circulation in the southern hemisphere, especially in view of the fact that all the important works available come from the northern hemisphere and have to be re-interpreted from the southern point of view.

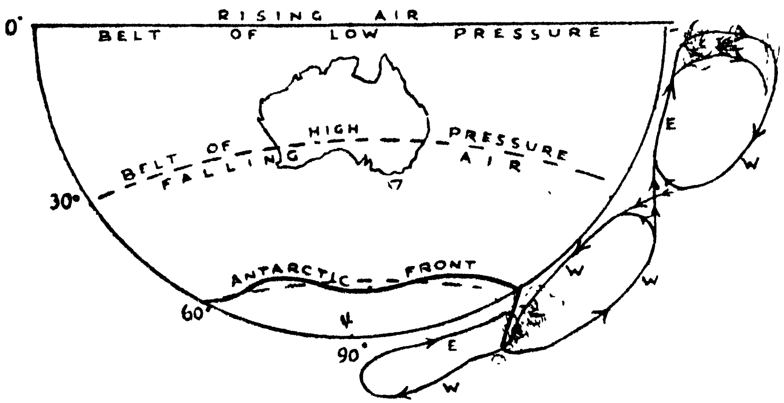


Fig. 1. General pattern of air circulation in the southern hemisphere. Note that a belt of falling air around 30°S. is postulated as essential to the whole circulation system. Also note that the Antarctic front lies near 60°S., quite far from Australia

The general pattern of a hemisphere's air circulation and its subdivision into three cells have been fully described by Rossby[3], and all that is required here is a revision of the diagram for the southern hemisphere (Figure 1). Several features must be clearly understood. Firstly, surface air circulation primarily consists of prevailing easterlies between 0° and 30° S. (" trades ") and between about 60° and 90° S. (" blizzards "), these latitudes being taken as average; westerlies prevail between about 30° and 60° S. Secondly, upper air circulation consists entirely of westerlies, except very near the equator. There is a belt of falling air about 30° S. and this belt is a necessary feature of the whole

circulation scheme. Finally, there is a definite wavy front about 60° S. where prevailing easterlies and prevailing westerlies meet, clash, and cause front formation and precipitation; incursions of cold easterly air may actually occur much further north at times.

An aspect which most northern-hemisphere workers have not stressed—because it does not affect any country near North America or Europe—is the different height reached by the circulating air near the equator and further away ; Rossby for instance[3] states that above 4 or 5 kilometres westerly winds prevail at all latitudes. On the other hand, a clear diagram showing an easterly circulation near the equator, but without a full discussion of its significance, is given by Miller[4]. Actual observations of upper winds in the intertropical regions show that easterly winds may prevail even at 16,000ft.[5] Evidently the belt of rising air near the equator reaches a greater height than any other part of the general air circulation, as may be expected because of the greater rarefaction of the air due to heating, the stronger centrifugal force at low latitudes, and the upward push due to more air rising from below. Besides, air does not just rise sharply at the thermal equator, but begins to rise as soon as it warms up sufficiently.

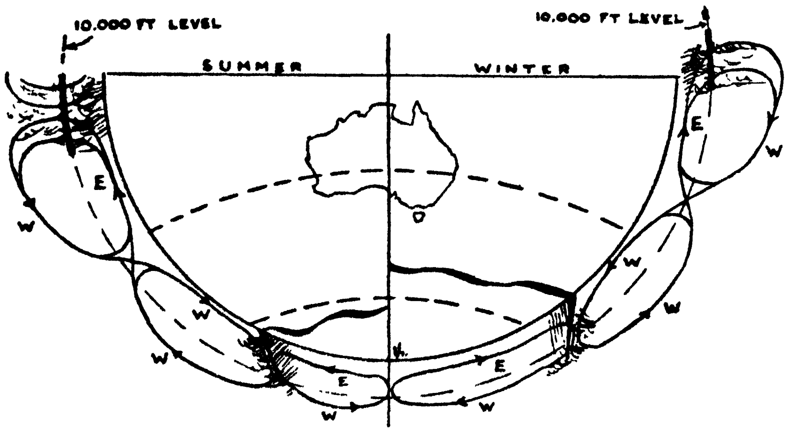


Fig. 2. Summer and winter patterns of air circulation. Note the shift in latitude of every air belt, and the contraction (summer) and expansion (winter) of antarctic air. The westerlies at 10,000ft. are shown by a thin broken line, the easterlies at the same level by a thick continuous line

We can now compile another diagram (Figure 2) for summer and winter circulation. The exact extent of the seasonal swing of the various air belts cannot be determined for any specified time because it varies continuously, but average positions may be assessed. We then find that while the area of prevailing polar easterlies contracts in summer and expands in winter, other planetary air belts do not vary greatly in area ; their change of latitude from summer to winter may be easily obtained from the diagram itself.

If we follow the 10,000-ft. level through the several air belts, we find that it corresponds to westerly winds at all but the low latitudes. In summer,

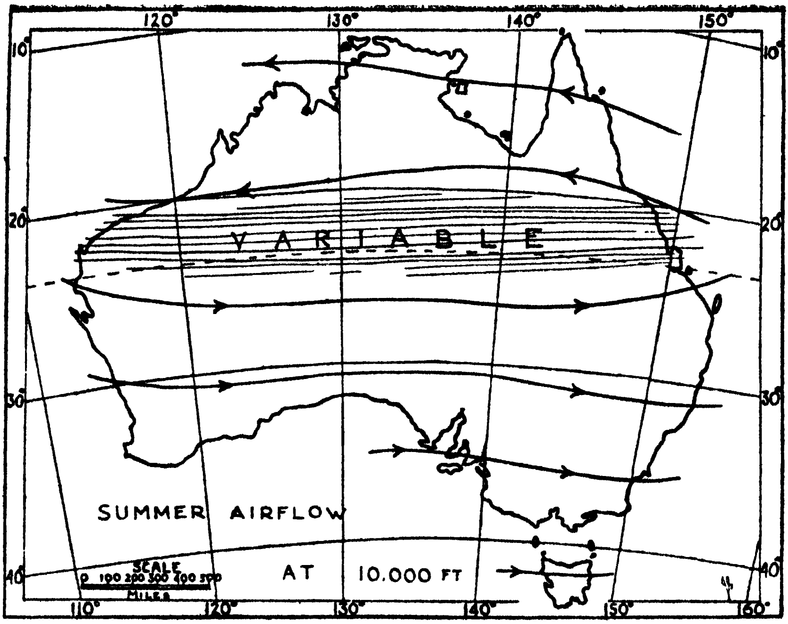


Fig. 3. Summer airflow at 10,000 ft

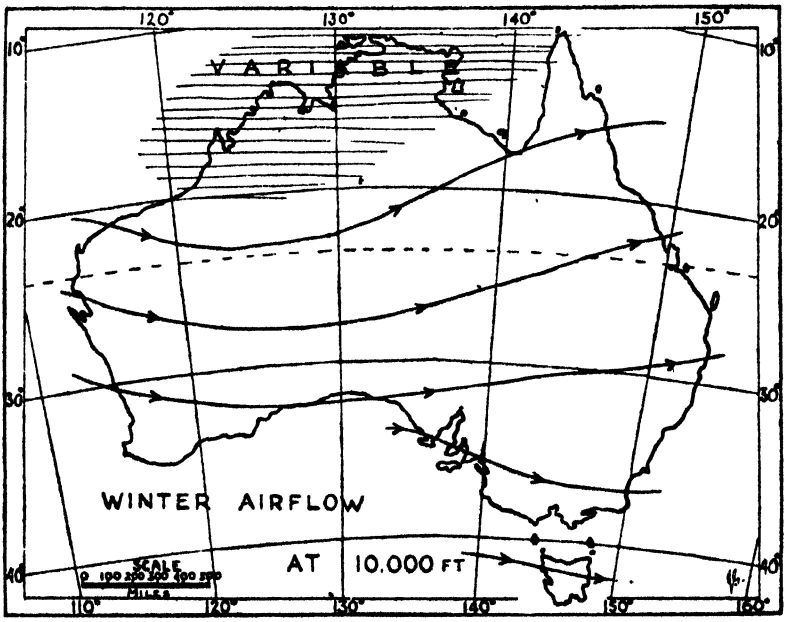


Fig. 4. Winter airflow at 10,000 ft

easterlies prevail as far south as about 20° S ; in winter, they move northwards and only prevail north of about 5° S. The same diagram shows the upper-air westerlies by a thin broken line, while the upper-air easterlies are shown by a thick continuous line.

The easterlies correspond to the belt of convectional ascent, and are due to a westward-upward movement of the air where the trades reach the hot regions of the world. The diagram also shows the well-known convectional cloudiness and rain.

A disturbing factor is introduced by the monsoon, and until more exact and numerous upper-air observations become available from these regions, the height at which monsoonal effects cease to be noticed cannot be assessed. However, it is obvious that the corridor between Asia and Australia is likely to be affected by the monsoon at fairly high levels.

The theoretical postulates embodied in Figure 2 seem to be confirmed by a detailed analysis of the airflow at 10,000ft. from the data available at the present moment[5] ; the geographical interpretation of this analysis is shown in Figures 3 and 4.

It is now possible tentatively to outline the main aspects of the surface air circulation in the southern hemisphere. The method of analysis corresponds in a general way to that followed by Petterssen in his study of the air circulation in the northern hemisphere[6]. In the course of the preliminary work, the basic averages mapped out by Shaw[7] have been brought to date whenever possible.

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1. SCHOTT, G. : *Geographie des Indischen und Stillen Ozeans*, Hamburg, 1935.
2. U.S. WEATHER BUREAU : *Atlas of Climatic Charts of the Oceans*, Washington 1938.
3. ROSSBY, C. G. : *The Scientific Basis of Modern Meteorology*, published as a chapter in *Climate and Man*, Washington. 1941.
4. MILLER, A. A. : *Climatology*, London 1946.
5. R.A.A.F. : *Weather on the Australia Station*, Melbourne s.d.
6. PETTERSSEN, S. : *Weather Analysis and Forecasting*, New York 1940.
7. SHAW, N., in collaboration with AUSTIN, ELAINE : *Comparative Meteorology*, Cambridge, 1942.

This article will be concluded, next month, with a discussion of the air masses and their sources.

A MILLIBAR BAROMETER FOR THE AMATEUR

By C. A. Wood

A good barometer, graduated in millibars, is an essential part of the meteorologist's equipment, yet so often (such is the way of meteorologists) the enthusiastic but impecunious amateur meteorologist finds himself without the wherewithal to purchase this indispensable item. I frequently receive letters from correspondents, asking for my advice on the matter, and up till now I have always had to return the same discouraging answer : if you want a good barometer, you must be prepared to pay for it.

At last, however, I can give better news. Plate IIIA shows the answer to the amateur meteorologist's prayer : a first-class, highly sensitive yet robust aneroid barometer, with a sub-scale graduated in millibars, for less than twenty shillings. If you are fortunate, you will be able to mount it, as shown, in an old clock case ; if you are a bit of a handyman, you can make a case for it from a few small pieces of oak or mahogany ; and if you have a few shillings extra, and you have neither an old clock case nor the skill with tools to make one, your local woodwork expert will doubtless oblige.

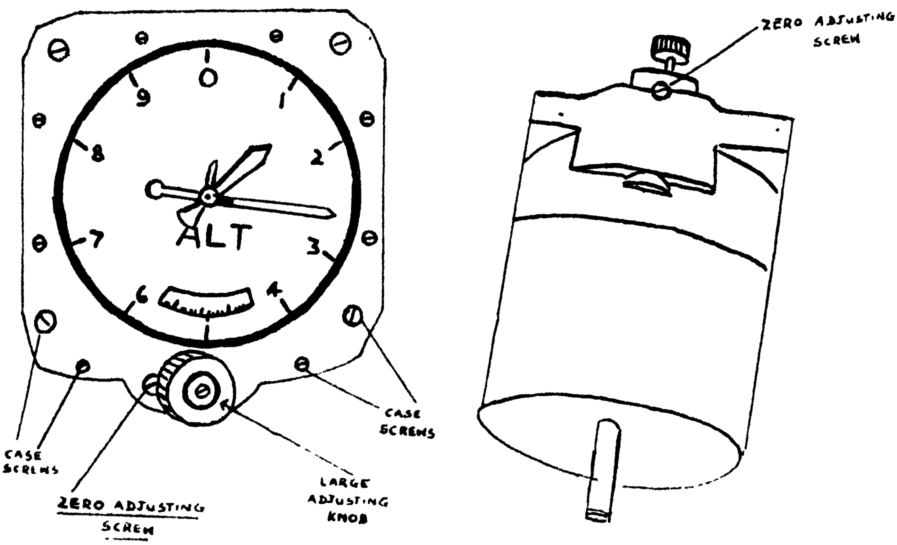
The barometer consists of an aircraft altimeter of the " sensitive " type ; the one shown is a Smith's Mark XIVA, and the dial is luminous. The millibar sub-scale can be clearly seen beneath the word " ALT " in the picture. Almost identical with the one shown is the Kollsman Mark XIVA altimeter, manufactured by an American firm. The mechanism of these instruments is a masterpiece of precision engineering, and incorporates a pair of aneroid capsules, which are linked together and geared up to the hands of the altimeter through an intricate system of levers and wheels. The mechanism is totally enclosed in a polished black bakelite case, even a fine-mesh dust filter being provided in the rear of the case, over the air inlet hole. I would, however, recommend readers to take my word for this, and not to start removing the face and tinkering with the works unless they have—as luckily I have—a watchmaker friend who is also an ex-R.A F. instrument maker !

The method of using the altimeter as a barometer is simple. If the hands are set by means of the large adjusting knob (visible in the photograph at the bottom of the dial) to read the height of the particular place in feet (a glance at an Ordnance map, or a word with your local surveyor will elicit this information), the millibar scale will show the Mean Sea Level air pressure, which is the one used in plotting synoptic weather charts and drawing isobars. You can check that this is so by comparing the reading so obtained with the " QFF " of your nearest aerodrome—this can be taken from the *Airmet* broadcast at any hour of the day. Be sure, however, to choose a day when the pressure of the air is not changing rapidly—preferably an anticyclonic day, and certainly not a day when a vigorous depression is approaching. If you have plotted an *Airmet* chart (see *Weather*, Vol. III, No. 9, pp. 270-277 ; Sep., 1948), you will be able to ascertain the Mean Sea Level pressure of your district from the isobars.

Having performed this check, should you find your barometer is several millibars out, adjust it as follows :—

(*a*) Smith's Type Altimeter.

1. Turn the large adjusting knob until the millibar sub-scale shows the correct reading, as determined from the " Airmet " broadcast.
2. Slacken zero adjusting screw (see diagram) three *full* turns. This disengages the mechanism controlling the hands from that of the millibar scale.
3. Set hands to read the height in feet of your own particular situation, by means of the large adjusting knob, tapping the instrument as you do so, to obtain a correct setting.
4. Tighten zero adjusting screw.



a. "Smith's" type altimeter b. "Kollsman" type altimeter

Fig. 1. To illustrate position of zero-adjusting screw

(*b*) Kollsman Type Altimeter.

(These may be distinguished by the letter " K " moulded in the bakelite on the back of the case.)

1. Set hands to read the height, in feet, of your own particular situation, by means of the large adjusting knob, tapping the instrument as you do so to obtain correct setting.
2. Slacken zero adjusting screw (see diagram) three *full* turns.
3. Pull out the large adjusting knob. This disengages the mechanism controlling the hands from that of the millibar scale. It is rather like altering the hands of a watch.
4. Keeping the large adjusting knob pulled out, turn the knob the required way, until the millibar scale reads the correct pressure, as determined from the Airmet broadcast. The *hands* will not move from your original setting as you do this.
5. Release large adjusting knob, and tighten zero adjusting screw.

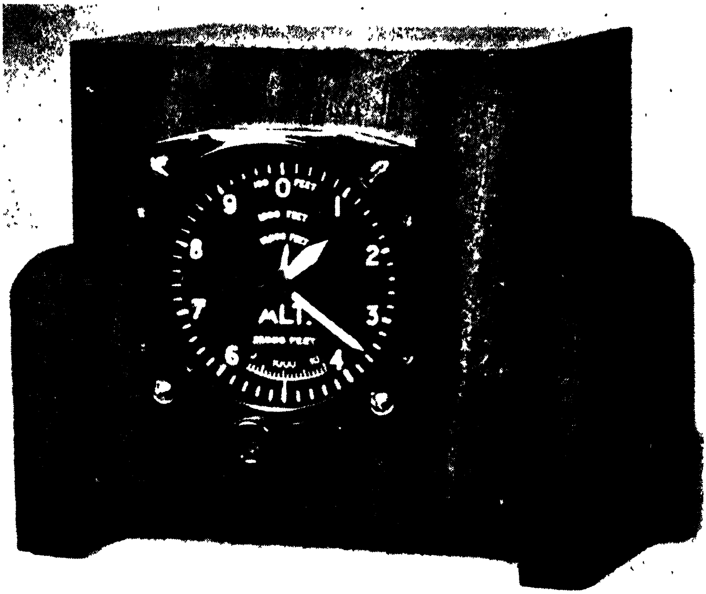
It will be seen that the Kollsman type altimeter requires a method of setting that is in some ways the reverse of the Smith's type, but a few minutes' experimentation will familiarize the reader with the procedure. It may be that the zero adjusting screw is buried under a small seal of coloured wax; if so the seal should be broken with the point of the screwdriver to expose the screw.

Another method of using the altimeter as a weather glass is to set the hands to zero from time to time, by means of the large adjusting knob, and notice whether the large hand moves, over a period of hours, clockwise or anticlockwise; if it moves clockwise—that is to say, from 0 to 1, and from 1 to 2, and so on—then the air pressure is falling, and the chances are that a depression or a trough of low pressure is approaching, with deteriorating weather and probably rain. If the hand moves anticlockwise, however—that is, from 0 to 9, and from 9 to 8, and so on—then the air pressure is rising and it is likely that a ridge of high pressure or an anticyclone is coming in, with improving weather. The instrument will show, in short, the *barometer characteristic*, as the professional meteorologist calls it—i.e. whether the pressure of the air is rising or falling. This is the most important thing about any barometer—the height of the barometer is indeed of little value in forecasting, as is well known to those who have been misled by the "Wet, Change, Stormy" inscriptions of the ordinary house barometer which are based on the entirely erroneous assumption that certain air pressures indicate certain fixed types of weather.

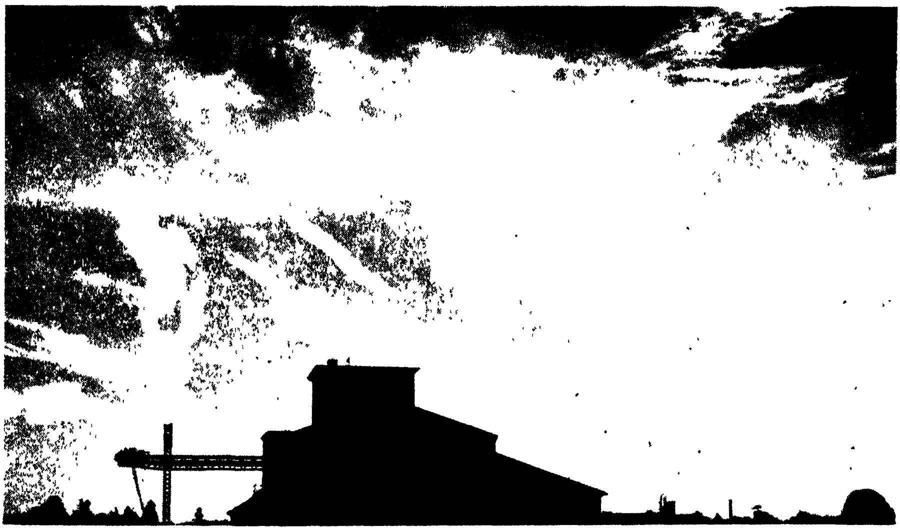
Now to the crucial question: where to obtain these altimeters. They are available from several firms who specialize in the sale of ex-R.A.F. surplus stores, and usually cost about 17s. 6d., plus 9d. or 1s. for postage. There are on the market other types of altimeters, the so-called "non-sensitive" types, at about 5s., but while these could probably be adapted for use as a home-made barograph, given (again) a watchmaker friend who would modify an eight-day clock to rotate a chart-drum, they are not recommended for use as an ordinary barometer if a Mark XIVA type is obtainable. When purchasing, a Mark XIVA type should be specified, and it is a wise precaution to send an extra copper or two, with a request that the firm dispatch the altimeter by registered post, marked "Fragile—Handle With Care." The instrument should be examined on receipt to see that the case is not cracked, and that the hands swing freely when the adjusting knob is turned—I make these suggestions as a result of hard experience!

As can be seen, an attractive piece of furniture can result from the method used to encase the altimeter. As the instruments are compensated for temperature changes, they can be placed in any suitable position in the living-room. Contrary to popular belief, there is no need to keep a barometer in chilly solitude in the hall! The instrument should be tapped gently before reading—the official way as well as the general custom.

[Readers who have difficulty in obtaining an altimeter are invited to send a stamped addressed envelope to *Weather* asking for the name of a firm who can supply suitable instruments.—EDITORS]



A. The Millibar Barometer mounted in an old clock case



B. Condensation trails at Farnborough, the venue of the summer outing of the Royal Meteorological Society (see page 251)

PLATE III

Fig. 1.
The S.E.I. Photometer. It is 7 in. high, 1½ in. diam. and weighs about 1¼lb

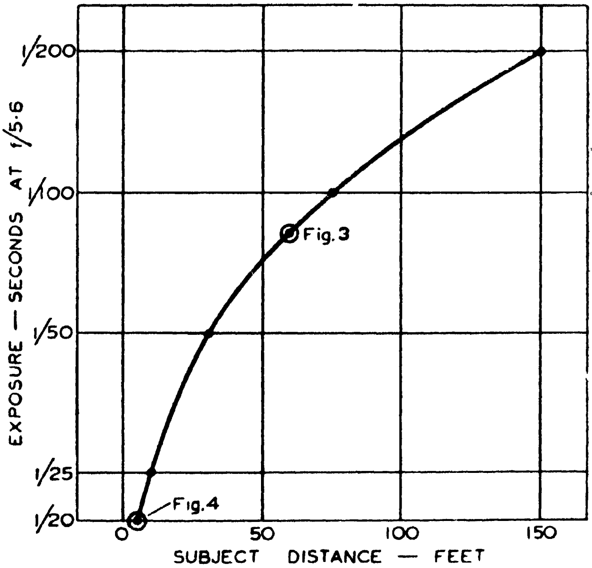
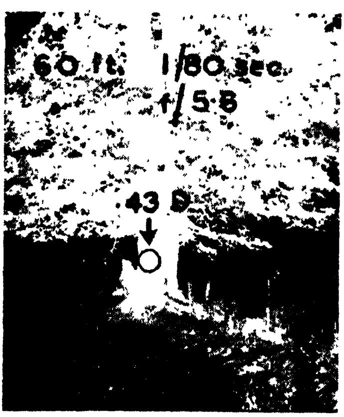
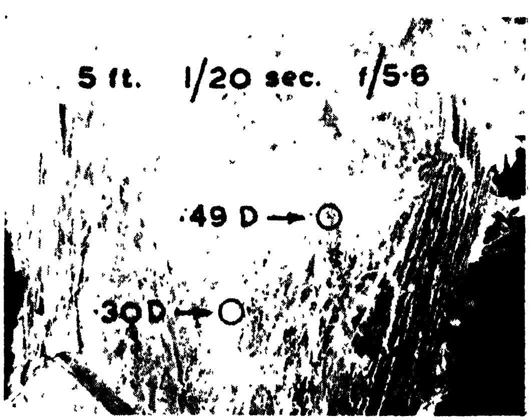


Fig. 2. The curve shows, for a particular case, the relationship between subject-distance and exposure as indicated by the photometer when matched from the camera on the darkest shadow (the tree-trunk in Figs. 3 and 4). The greater the subject distance the brighter the shadows become, because of the increased depth of haze between the camera and the subject. The dots show the points measured (and through which the curve, giving constant tree-trunk negative density, was drawn), and the rings show the points checked photographically (Figs. 3 and 4)

Fig. 3. Check negative taken at 60 ft from the tree. The area matched with the photometer at the camera was that within the black circle. The subsequently measured negative density at this point is shown. The amount of haze present would be classified as "slight"

Fig. 4 The same subject as Fig 3, but taken from 5 ft. It will be seen that the average tree-trunk negative density is practically the same as in Fig. 3, but the exposure indicated and given was four times greater





EFFECT OF HAZE ON PHOTOGRAPHIC EXPOSURE

THE S.E.I PHOTOMETER

A new type of selective Photographic Exposure and Brightness Meter

No doubt many readers who are keen photographers, and who have used the conventional type of photo-electric exposure meter, have often wondered how an accurate result can possibly be obtained from an instrument which accepts such a large angle of light from the subject, and whose indicated reading is therefore influenced by the brightness *distribution* in the subject as well as by the brightness *levels* of the various tones present. The fact is, of course, that the true criterion for correct exposure is either the darkest significant shadow tone or the brightest highlight, depending upon the application. In general, the shadow method is best for ordinary negative materials from which black-and-white prints are made, and the highlight method is applicable to reversal materials including all colour films used in amateur cameras.

It is unsatisfactory in most cases, however, to use an ordinary photo-electric meter to determine the shadow brightness by approaching a dark shadow in the subject, even though a factor is applied to allow for the different method of application to that for which the meter was calibrated. This is because the amount of haze between the subject and the camera has a much greater brightening effect on the darkest shadows than may be supposed, particularly in the case of medium or long-distance shots, and a close-up shadow reading for a distant shot will therefore indicate a much longer exposure than is necessary. Furthermore, close-up readings obtained from the darkest shadows are frequently so low that their accuracy is often in doubt.

The new S.E.I exposure meter completely avoids all the above problems because its acceptance angle, instead of the usual 40° to 100°, is only ½°, allowing it always to be used from the camera position. It is an instrument of the true photometer type, where the image of the subject is viewed through a short telescope and a small comparison " spot " is seen superimposed in the centre of the image field. The spot is illuminated by a bulb operated by a standard U2 size dry battery inside the body of the instrument when the switch button in the base is pressed. By then rotating the base while the button is still pressed the spot brightness is varied until it *matches* (*i.e.* is neither darker nor lighter than) the brightness of the particular part of the image immediately surrounding it, this control being effected by means of two neutral photometric wedges which slide one over the other.

By an arrangement of neutral filters three ranges are provided which give a continuous total range of 1 to 1,000,000, allowing the darkest shadows of very dark interiors, bright clouds near the sun and any tone in between to be accommodated. A photo-electric cell device makes the reading independent of the state of the dry battery or the condition of the lamp, while " spot " colour-correcting filters facilitate measurements in daylight or artificial light.

The scales, which are linear throughout the whole range of the instrument, cover exposure-time, lens-aperture and film-speed, the latter being marked in the new British Standard Exposure Indices. Foot-lambert (brightness) and density (photographic) scales are also provided for more specialized applications.

The illustrations show how easily the S.E.I Photometer can be used to demonstrate the effect of haze between camera and subject, as mentioned earlier, and this may, perhaps, point the way to applications of haze-comparison measurements for meteorological work taken, say, by measuring the relative brightness of two hooded black surfaces placed at fixed distances, one close to the observer and the other at a distance.

From a purely photographic point of view it will be realized that this type of photometer can be used to obtain highly consistent results, because the particular object matched will—given consistent materials and processing—always be reproduced at a consistent negative density. It can also be used for the close control of projection-printing exposures and, with the aid of accessories shortly to become available, for the measurement of transmission and reflection density, the measurable area in this application being less than 1/100 inch in diameter. The instrument is finding many applications in industry, both in the photographic and illuminating engineering fields.

LETTERS TO THE EDITORS

Antic Theodolite

"Will you allow a brain-weary student to let his imagination run riot? For I was interested in the concluding article in the June issue of *Weather* on "Pilot Balloon Theodolite Development," and particularly in the picture with the caption "Taking Observations with a Pilot Balloon Theodolite." And, on closer study, I find myself wondering what synoptic situation produced a reversal of wind direction with height and a fairly strong wind from between north and east above this reversal. I assume, incidentally, that the observer was watching a balloon, for the nature of the clouds makes it unlikely that a nephoscope observation was in progress.

Let us assemble the evidence :—

(i) From the shadows cast by the switches we see that the elevation of the sun was about 50° (perhaps more); thus the observation was being done about midday in summer or late spring, probably in the south of England.

(ii) Assuming midday, the balloon lies within a point or two of SW. from the theodolite and its elevation is quite low, perhaps less than 20°. We note that the observer is well-trained and watches with her right eye open, but this suggests that the balloon (presumably red, 90 in.) is not too far away, say not more than 6 miles, giving a height of under 10,000 ft.

(iii) Seasoned observers will recall that as the balloon is released the observer positions himself so that it goes away to the left. Thus, in this case, it has come back over the theodolite. So it appears probable that there was an average wind of about 25 to 30 m.p.h. from between north and east over a few thousand feet below 10,000 ft.

What could be the situation which gave these conditions? Perhaps it was a sea breeze at a west coast station with a ridge over Scotland from the Azores anticyclone. Or was the upper cloud associated with a high-level depression over France. I wonder?

But . . . could it, perhaps, be that there was no balloon? I hope not—it has given me such pleasure to dwell upon the cheerfulness and enthusiasm of the observer—and in any case, I should hate to think that this, my first, and perhaps my last, piece of research, had been of no avail.

London R. H. ELDRIDGE

[We have not referred this to the writer of the article but, to a girl with a smile like that, surely most things are possible?—EDITORS]

Reflections in Kenya

You might think that, to a large extent, we had escaped from weather as a topic of conversation. Actually it is not so. If anything, it seems to play a bigger part in life out here than in England. The dry weather we encountered during the early months of the year was held to be entirely responsible for every ailment, every business failure and every outbreak of nerves. Later, the rains broke and the ailments, bankruptcies and displays of temper were then attributed to the "change in the weather". Still later, the rains failed and, needless to say, brought the same crop of misfortunes. Now it is raining again and so we go on.

The following little story illustrates how really vital weather is in our daily lives. My friend Arthur Hill's farm was next to that of Peppery Colonel No. 1 who, in turn, had a neighbour called Not-so-Peppery Colonel No. 2. After a shower, No. 2 met No. 1 (hot foot from the rain gauge) and enquired pleasantly "Had any rain?" Said No. 1 proudly, "Yes, by Gad, sir—point six five, what about you?" Said No. 2, smugly, "I measured one point two inches". Said No. 1, later to my friend "Hill, I could have struck him!"

Nakuru, Kenya — A. K. Rittener

A Miniature Thunderstorm

With regard to the frequent discussions on strange thunderstorms occurring from time to time, I wonder if anyone can quote experiences similar to a strange occurrence witnessed by myself a year or two after the first World War.

I was staying at Stockton Heath, Cheshire, in July, about 100 yards from the Manchester Ship Canal. The evening was somewhat oppressive, and the air had become strangely still. Gazing down the road, I saw a small black thundercloud gathering along the length of the Canal, and about 30 or 40 ft. above it. It was approximately 100 yards long and perhaps 6 ft. thick. As I gazed at this strange formation, a dazzling lightning flash raced through the entire cloud, i.e. parallel to the water, and a bang like the discharge of field artillery followed immediately. About 40 seconds later, another flash and report occurred; then the cloud thinned and dispersed in about four minutes.

I might add, that at least in those days an air-current of varying intensity moved up that Canal almost incessantly, i.e. inland towards Manchester, at the Stockton Heath section—one felt it on the neighbouring bridge. (Incidentally, a year or two later, a "thunderbolt" fell in an adjacent road.) I have often wondered since, to what extent, and in what way, water-evaporation at that point contributed to the occurrence. The evening (7 p.m.) was dry.

Belfast — C. S. Bailey

Tails From Cumulus Cloud

To delve into the mysteries of the physics of clouds is a fascinating study. In *Weather* of October 1948, Mr. Colin H. Taylor reported that he had seen "small fair-weather cumulus with perpendicular tails hanging from their bases." He concluded his interesting letter by requesting someone "to explain the cause and conditions necessary for the formation of the tails. Is the presence of the phenomenon indicative of the strength of the up-currents under the cloud, thus making it suitable for use by a sail-plane pilot?" he asked.

I think the answer to this interesting query is to be found in the *Quart. J. R. Met. Soc.*, Vol. 63, p. 115. Also in the *Q.J.*, the widow of a glider pilot forwarded his notes on the physical conditions near clouds to the Royal Meteorological Society.

The most interesting item arising from these notes was his account of a milky-white vapour which he found extending downwards from the under surface of most active clouds. In some places this extended to as much as 100 feet from the true base, and could actually be seen rising into the cloud proper. The pilot's view was that this vapour represented the transition stage from the first visual condensation to the actual cloud drop.

He added that this phenomenon had been most useful to him on many occasions, as showing that a cloud was still in a process of formation.

In his notes, the pilot commented on the violent ascending currents sometimes to be found in clouds, and one member of the Society suggested that the sudden reversal of vertical motion at the edge of a cloud, which so many glider pilots have observed, is inconsistent with the continuity within a cell of unstable air, such as may be observed in a laboratory.

Melrose, Roxburghshire — G. Bain Ross

Sunspots and Dry Spells

It may be somewhat premature, but in view of the widespread drought which is steadily developing during the present summer, not only in the British Isles but apparently elsewhere in the Northern hemisphere, is it possible that markedly dry conditions tend to set in about *three years* after sunspot maxima ?

I have just looked up the dates. They occurred in 1860-1, 1883-9, 1894-1, 1917-6, 1928-4, 1937-4, and, of course, 1946, with its giants. I remember some of the following summers well: 1921 was glorious with extraordinarily low rainfall figures up and down the country. A severe drought set in early in 1932 (after several miserable summers). 1940 gave us the wonderful Battle of Britain months of fine weather. The records sing the praises of the two Jubilee summers, 1887 and 1897, in respect of freedom from rain for lengthly spells ; and my father often spoke of an exceedingly dry 1863 in South England.

Belfast C. S. BAILEY

The inter-relationship of sunspot activity and variation in world weather patterns is put forward in an interesting paper by H. C. Willett (*J. Met.*, 1949, Vol. 6, No. 1, p. 34)—EDITORS

June Sun-power

During the recent June of 1949 I gained the impression though not, perhaps, so strongly as I did in June 1914 that the solstitial power of the solar rays was exceptionally great, and would like to know whether this impression will eventually be supported by instrumented records as it certainly was to a remarkable degree in 1914 (*Meteorological Magazine* 1920). It should be noted that casual observation of this kind is far more likely to be reliable on cool days with an air temperature not much above 70° than on really hot days when the sun will always feel oppressively hot even at the equinoxes.

It is just this which gave point to the case of 1914. The mean air temperature of that month was only a degree or so above the normal and there were only a few very hot days as on the 30th when the maximum nearly reached 90°. Yet throughout that June the sun smote with a solstitial fierceness, even on the numerous fresh or cool days, which has made me remember it as the most magnificent midsummer month in my whole long experience of the climate of London. It was flaring "flaming June" full of high lights and midsummer pomps !

Well do I remember the exquisite blue of the sky on the evening of Saturday 13 June 1914. Next morning broke rather cloudy with a fresh NE. wind, but before noon the air suddenly became sultry as there developed over the south-western districts of London an extremely violent thunderstorm with several lightning fatalities at Wimbledon and Richmond. I happened to be at St. Albans, Herts., that Sunday afternoon and shall never forget the imposing pile of thunder clouds that marked the creation of that great storm to the south.

Hampstead L. C. W. BONACINA

Airmet and its Uses

Lieut. Cdr. P. C. Spink's last paragraph in his article "Airmet and its Uses" will, I am sure, be endorsed by many amateur meteorologists. For instance, though bearing in mind the primary function of the service, I wonder whether the identification letters attached to systems and fronts in the charts of the *Daily Weather Report* could be used by the forecaster in his references to pressure distribution, if not in all broadcasts then at fixed times, *e.g.* the barren ten minutes following 0720 and 0740, one of the midday periods and in the final broadcast of the day. I feel this would be of considerable value to subscribers to the *Daily Weather Report* and would surely be of assistance to others.

The inclusion of four additional station reports—one each from SW. Norway, Iceland and/or Faroes, a weather ship and Azores—seems to me more desirable than detailed surface wind data, however.

Leicester E. A. BONSER

8,500 years ago

May I draw attention to a statement on page 205 of *Weather* for July 1949, referring to the "end of the last advance of the Quaternary Ice Age some 6,500 years ago" ? Dr. Brooks, in the 1926 edition of his *Climate through the Ages* (p. 337) gives this date as 6500 B.C., and although I have not access to the work of Baron de Geer, this view is supported by other eminent authorities.

I feel that this point should be cleared up, especially as this is one of the rare instances in which geological chronology can be stated with some degree of exactitude.

Bedford J. E. ORD

SEPTEMBER 1949

WEATHER

Vol. IV No. 9

CONTENTS

EDITORIAL

While our monthly weather articles bring out some of the outstanding features of the weather, they afford little scope for reviewing exceptionally long phases which have so much influence on the life of the community. While there is promise of a good grain harvest, the potato yield is likely to be poor and green vegetables in short supply because of the difficulty of planting out in the hard ground. There have been widespread restrictions on the use of water, but the summer has been exceptionally good for holidays. What are the outstanding features of recent weather ?

The duration of bright sunshine has exceeded the average over Great Britain in each of the last nine months since November, 1948. This excess of sunshine over England and Wales was especially noteworthy this year in January, February, June and July, because in recent years these months have usually given less than average.

The mean temperature over Great Britain has exceeded the average in as many as 24 out of the last 28 months since April, 1947, and the deficiencies in the remaining four months, June, July and August, 1948 and March, 1949, were quite small. We shall not take kindly to colder months, when they recur, having become partially acclimatized to these more genial conditions.

The large amounts of sunshine and the greater warmth have resulted in high evaporation losses. At Camden Square (London) the total evaporation in July, 1949, from a free water surface was greater than that recorded in any month since records commenced in 1885, the next largest value being in July, 1911.

The rainfall picture cannot be dealt with so simply. In Scotland the total rainfall from January to July, 1949, closely approximated to the average, but over England and Wales it was 5 in. less than the average for that period. In most parts of Scotland each of the three months May, June and July, 1949, gave large deficiencies. Even in parts of the Western Highlands there were shortages of water, *e.g.* at Lochgilphead in Argyll, the supply reservoir became practically empty. Over England and Wales the rainfall of six of the last eight winter half-years has been less than average, with consequent effects on underground storage, mainly dependent on winter rains. At Camden Square the total rainfall January to July, 1949, was only 7·6 in., the smallest total in similar periods during the last 90 years, apart from 1921 with 6·7 in.

RED SKY AND FRONTAL SHADOWS

By D. J. Schove, B.Sc.

When it is evening, ye say, it will be fair weather for the sky is red ; and in the morning it will be foul weather to-day for the sky is red and lowering.

—St. Matthew XVI 2-3

During the recent war when official forecasts were censored many turned to the meteorological maxims of folk lore, such as were familiar in the time of Christ. The antithesis quoted above from the Bible is probably earlier, for in 300 B.C. Aristotle's successor, Theophrastus, singled out as the surest sign of rain "redness of the sky and cloud at dawn". In modern England we have the well-known rhyme :—

Red sky at night, Shepherd's delight,
Red sky in the morning, Shepherd's warning.

In some isolated places such as Prague and Aleppo the rule is reversed. However, this may be merely for reasons of rhyme, and generally speaking the red sky rules are found all over Europe and the Mediterranean.

CONVENTIONAL EXPLANATIONS

The practical value of this rule in war-time led to a question sent to the B.B.C. Brains Trust as to why the rule was true. The question master, Donald McCullough, had before the broadcast asked the Meteorological Office for an official opinion, and was able to assure the learned group that the rule was indeed true "seven times out of ten". Professor Joad thereupon elaborated an ingenious argument which (to his own surprise) was accepted by the question master as consistent with the "official meteorological view".

The conventional explanation associates the redness with the presence of dust or water droplets. Dust can explain the redness, especially of the sun's orb. However, as we noticed when looking for sunspots in early February, such redness can be a symptom of *fine* weather either at sunset or sunrise. In fact, in S.E. Australia redness of the rising sun is a sign of *heat*—a sign of hot dusty winds from the dry interior.

Meteorologists unable to associate a dusty dawn with a deep depression adopt a double view. Minnaert, in his *Light and Colour in the Open Air* says (p. 280)"......in the morning there is not much dust and a red colour must then be due to water droplets." Professor G. H. T. Kimble, in a newly annotated edition of *The Shepherd of Banbury's Rules* (Reading, 1941), adopts a similar idea. W. J. Humphreys tries to maintain that "light red clear" sunrises mean fine weather and "sombre red cloudy" sunrises mean rain. Professor Brunt (see *Weather* May 1946 p.14.) gives separate theories for red sunrises and sunsets, maintaining for the latter case " It is only in dry weather that the air contains large numbers of particles sufficiently small to scatter light."

The *Meteorological Glossary* tells us that the sunset maxim often proves "a broken reed" but a study of exceptions gives the clue to the real meaning of the rule. At school in East Anglia I found the sunset exceptions often occurred in early summer when secondaries moved up from the south ; this corresponds to the statement two centuries ago of Dr. Thomas Short that " Rain will follow.... if the sky....is red in the south or south east at sunset."

The various double theories seem to me unnecessary and the dust theory of no value. The best red sunsets often occur when the rain of a trailing front has ceased and the *clean* polar air from the Atlantic has arrived, whereas ominous red sun*rises* occur when *dry* dusty continental air moves north around depressions to the west.

FRONTAL SHADOWS—THEORY

The hypothesis of "Frontal Shadows" was found to explain both the red sky rules and the exceptions to the rules, and also to explain many other sunset (or sunrise) colours, notably green skies. A precipitating front is regarded as a solid, the shape of an inverted prism, casting a shadow—the "Frontal Shadow" —on one side and reflecting the sunlight from the undersurface of its upper cloud on the sunward side.

The composite diagram below illustrates merely the potentialities of the method. In the absence of frontal obstructions the solid line FTZP in the figure represents a ray from the sun. After grazing the surface of the earth at T it loses its short waves, by scattering, to the sky. TZP is a red ray which meeting cirrus cloud at Z illuminates its lower surface in crimson hues. Otherwise in a cloudless sky the red rays are scattered to give what is called the "purple light"; effectively the scattering layer can be regarded as a mirror in the lower stratosphere at P. An observer at O sees the purple light above P (to the left of P in the diagram) and the greenish twilight arch below it.

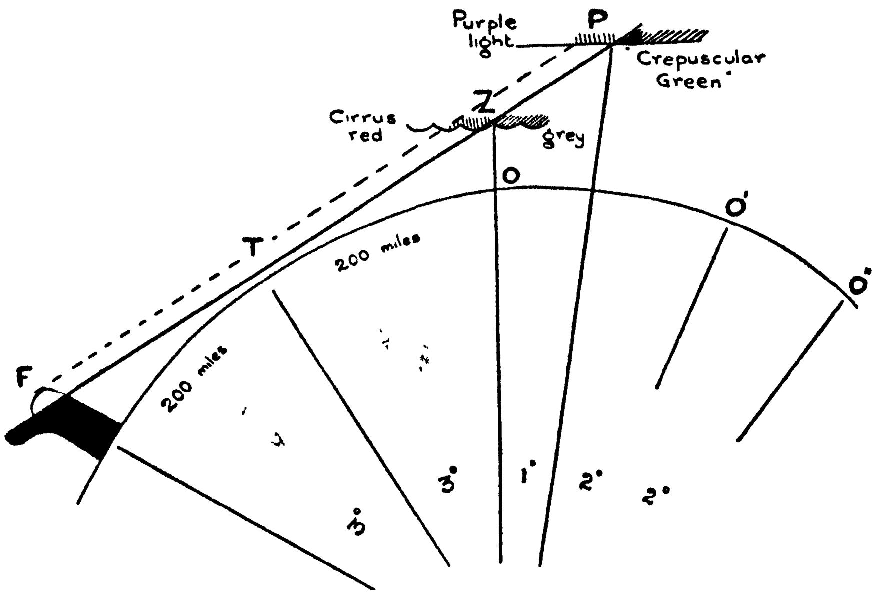


Fig. 1. The geometry of the Frontal Shadow at sunset—earth's curvature exaggerated. The solid line FTZP represents the rays unobstructed by nimbostratus, causing cirrus redness and "purple light". If this is cut off by a front at F the cirrus is yellow and the absence of the purple light gives a green sky at P.

O, O′, O″ represent alternative positions of the observer, about 400, 600 and 700 miles from the front respectively.

A frontal obstruction in the TZ belt, or even the cirrus from a front between P and O gives a *red sky* provided that the weather is clear to sunward. Hence in our latitude red sunsets are associated with fronts retreating eastwards.

A frontal obstruction at F cuts off all the rays between the solid and broken lines. In particular the sun's rays never reach T and are never reddened. Any cirrus therefore looks sickly yellow and becomes prematurely grey. The "purple light" does not appear and in its place we get a characteristic "twilight green"; it is no coincidence that W. H. Pick found empirically (*Quart. J. R. Met. S.*, 1930, pp. 350 and 364), that green skies occurred when there was stormy weather on the Atlantic. A weak front between F and T, without precipitation but with thin layer clouds, does not cut off the sun's redness, and the ray represented by the broken lines may be cut off while the full red ray *is* allowed to pass through. Fronts lying west-east through an anticyclone give particularly glorious effects.

I was able to discover some independent records of sunset colours from the Atlantic (1924-30) and from near London (1926). Moreover, careful measurements of the intensity and colour of skylight had been made on the Continent, and I compared some Berne data (1936-38) with the synoptic charts of the same dates. I found, as I had expected, that e.g. a cold front crossing the Bay of Biscay could cast a shadow in the sky that was observed (but not understood) by the scientists in Switzerland.

This claim sounds less extravagent when we consider the familiar green crepuscular 'rays' which can be produced by either mountains or cumulus below the horizon. Americans were once excited by strange streaks of shadow which reappeared every evening at sunset when there was no cloud for hundreds of miles. It was finally recognized that these streaks were the shadows of the Rocky Mountains projected far above the prairies to the east. We have no Rockies in this country, but towering castellated cumulus form over the Severn estuary on cool autumn evenings and they cast shadows which can sometimes be seen about 500 miles to the east. Minnaert, on p.227, describes the geometry of this phenomenon; the distance of clouds casting shadow rays on cirrus at a known height can easily be calculated. A cloud below the horizon, in the FT. belt, gives a crepuscular 'ray' TZP for an observer at O. In this same manner, ray-location of fronts is a practical possibility, the position O'' being that of an observer about 700 miles from the front.

Tropical storms give particularly good shadows and the red-sky rule should therefore prove useful in cyclone forecasting. The *Admiralty Weather Manual* merely tells us that cyclones are preceded by unusually red sunrises *and* (my italics) sunsets. Another writer states that green skies precede typhoons in the China Seas. I suggest that the colours depend on the direction of motion of the system. In the Equatorial belt, where systems move from east to west, the red sky rule should be reversed; green sunrises *precede* and red sunrises *follow* the hurricanes.

During my stay in the tropics I questioned native fishermen and farmers but was unable to discover any folk lore associated with sunrise or sunset. Red

skies are in fact rare and transient in a region where twilight is so short, and I was never posted on the path of a hurricane. Perhaps some reader of *Weather* in less fortunate "outposts" may be able to supply the missing evidence.

FRONTAL SHADOWS—APPLICATIONS

My use of these principles during the war in official forecasting was primarily a matter of experience. At first it was necessary to calculate the sun's angle of dip by the use of one's watch and *Nautical Almanac*, but with practice the angle could be guessed from twilight effects. By noting the various peculiarities, especially when there was a cirrus 'screen', a detailed analysis of the frontal situation a thousand miles to the west could sometimes be obtained before black-out. Our "Group" used to receive odd teleprinter messages such as :—

2100 G.M.T. 17/5/43 "Very rich purple light now showing suggesting 1000 miles of good weather to sunward"

On some occasions the shadows of a front would be seen e.g. only to the left of the sun, as on 23 June 1943, when at 2200 GMT a message was sent indicating the northern limit of the frontal rain. In those days there were no weather ships and frontal shadows were often picked up before the fronts had been marked on official maps or had affected West Ireland.

Sunset colours could thus play a useful part in official forecasting. There was a special code number in the 1920's by which enthusiastic seamen could record a red sunrise or sunset. This went the way of all codes, but sometimes it is possible to learn more about the situation by studying the sky than studying the chart.

SOME SOLAR AND TERRESTRIAL RELATIONSHIPS

By G. M. B. Dobson, D.Sc., F.R.S.*

We may, for convenience, divide the ways in which the sun can affect events on the earth into four groups :—

(1) through gravitational attraction to which, for instance, the solar part of the tides are due ;

(2) through the heat radiated by the sun which not only keeps the earth warm but supplies all the energy for the meteorological processes in the atmosphere ;

(3) through the sun's ultra-violet radiation which, though really a part of the heat radiation (and a very small part at that), may conveniently be treated separately ; for it is able to cause chemical and photoelectrical action in the upper atmosphere such as the formation of ozone and the ionization of the air ;

(4) through the emission of streams of electrically charged particles which strike the upper atmosphere and cause such phenomena as the aurora.

To these four groups we ought, perhaps, now to add a fifth which has only been known within the last few years, namely the emission by the sun

* Abridged from a Popular Lecture to the Royal Meteorological Society on 6 April 1949.

of radio waves which can be detected on the earth but are unlikely to cause any appreciable geophysical effects.

GRAVITATIONAL EFFECTS

Unlike the phenomena in the later groups, the gravitational force of the sun remains constant with time except for the small variation in distance of the earth from the sun. We should therefore not expect much change from day to day or from year to year from such causes. There is, nevertheless, one point about the solar tides which has only recently been cleared up, after bothering scientists for some time. Just as the gravitational forces of the sun and the moon cause tides in the oceans they also cause tides in the atmosphere. Now the tide-raising force of the moon—because it is so much nearer to the earth—is greater than that of the sun and, as everyone knows, the ocean tides are mainly governed by the moon. In the atmosphere, however, the tides due to the sun are much greater than those due to the moon. Figure 1b is an example, and any barograph record at a time when the pressure is fairly constant will show the same thing: there is a double oscillation of pressure with maxima about 10 and 22 hours and minima about 04 and 16 hours local time (Fig. 1a), while the lunar variations are invisible.

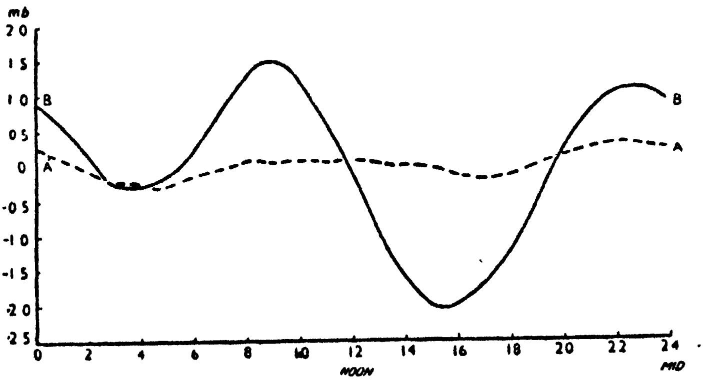


Fig. 1a. Evidence of solar tides in atmospheric pressure at different latitudes. AA—Aberdeen; BB—Batavia

It was at first supposed that the large solar atmospheric tide was the result of resonance between the natural oscillation time of the atmosphere and the solar period of 12 hours. Calculation, however, at first indicated that the atmosphere should have a natural period of about $10\frac{1}{2}$ hours, while for the necessary resonance it would have to have a natural period within a very few minutes of 12 hours. It was therefore suggested that the oscillation of the barograph was not a gravitational tide at all but was due to solar heating, though it seemed difficult to understand how solar heating could produce a symmetrical 12-hour oscillation through the night as well as through the day. Within the last few years it has become known that, owing to the absorption of solar ultra-violet radiation, the atmosphere above about 35 or 40 km. is as warm or warmer than the air at ground level, and it has recently been shown that if the upper atmosphere is warmer than the stratosphere the calculations

of the natural period of oscillation must be modified. The new calculations make it seem very much more likely that the atmosphere really has a natural period sufficiently near 12 hours to allow resonance with the solar tide-raising force and thus to account for the large solar tide.

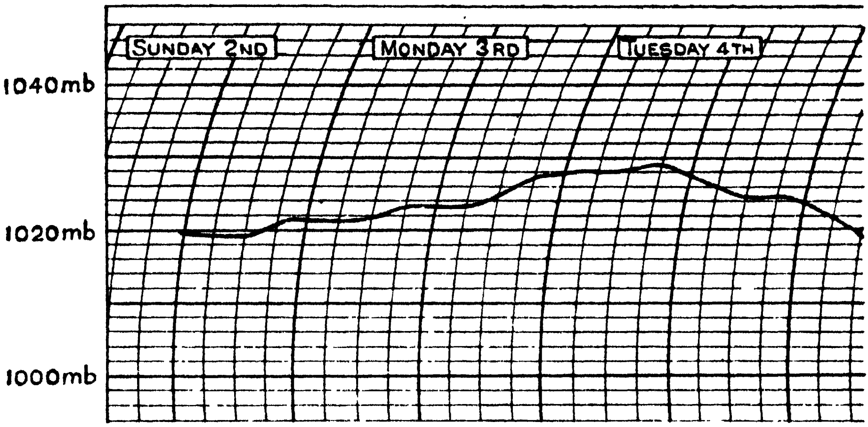


Fig. 1b. Part of a Barograph Trace for Shotover, Oxford, May 1943, showing small 12-hourly humps due to solar tides in the atmosphere

RADIATION OF HEAT BY THE SUN

Calculations of the amount of heat radiated by the sun and received on the outside of the earth's atmosphere are difficult to make owing to the variable absorption of energy in passing through the atmosphere. A great deal of effort has been expended by the Smithsonian Institution of America on such measurements and the name of Dr. Abbot—the present Secretary of the Institution—will always be associated with this work. It seems that there are small but real changes in the energy sent out by the sun amounting to, perhaps, one per cent. Figure 2 shows that between June and Nov. 1928

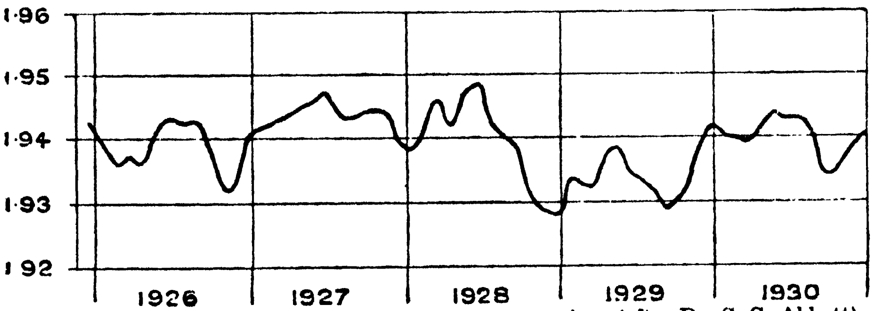
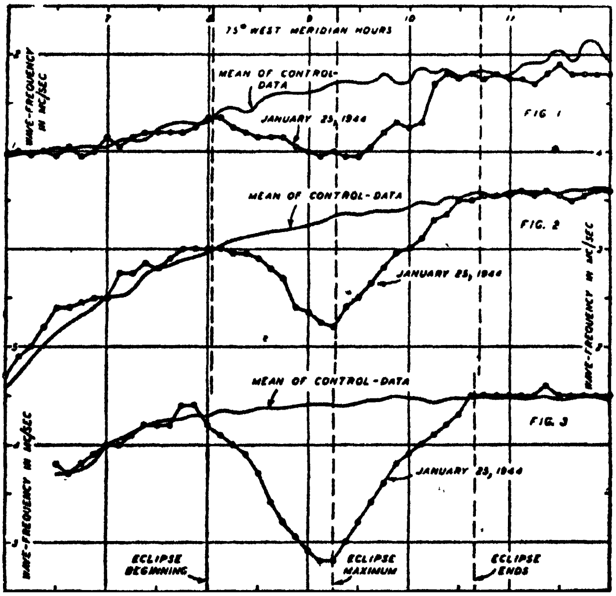


Fig. 2. Values of solar constant, average for three stations (after Dr. C. G. Abbott)

there was a steady fall in the radiation of about one per cent. and the average value was not reached again for about a year. A large enough change in the sun's radiation may, of course, be expected to have important effects on the weather, and it has been claimed that these changes in solar energy do affect the earth's weather ; but the effects are small and I think most meteorologists are still not convinced of their reality.

While the total heat radiation from the sun seldom changes by more than about one per cent, there is every reason for thinking that the ultra-violet part of that radiation varies very much more. Unfortunately the really active part of the sun's ultra-violet radiation is entirely absorbed by the upper atmosphere and as yet no measurements of its intensity have been made, though they may be possible in the near future by using rockets. We can, however, infer the changes in ultra-violet radiation from the effects produced in the upper atmosphere.

By sending radio signals into the upper atmosphere where they are reflected by the regions which are electrical conductors it is possible from the returned signal to determine the ionization at different levels. It is found that in the daytime there are four main regions of ionization : the " D Layer " probably at a height of about 60 to 70 km., the " E Layer " at about 120 km., the " F_1 Layer " at about 200 to 250 km. and the " F_2 Layer " at about 250 to 400 km. That the ionization of the three lower layers is really caused by ultra-violet light from the sun is clearly shown at times of a solar eclipse when the ionization decreases exactly in phase with the eclipse. This is evident in Figure 3. (The cause or causes of the F_2 layer is less certain.)



FIGS. 1-3—COMPARISON OF ECLIPSE OBSERVATIONS AT HUANCAYO MAGNETIC OBSERVATORY, JANUARY 25, 1944, WITH MEAN OF SIX CONTROL-DAYS, FOR MINIMUM FREQUENCY (FIG. 1), CRITICAL FREQUENCY E-REGION (FIG. 2), AND CRITICAL FREQUENCY F_1-REGION (FIG. 3)

Fig. 3. Effects of a Solar Eclipse on the Ionosphere (from the paper by Ledig, Jones, Giesecke and Chernosky in *Terrestrial Magnetism and Atmospheric Electricity*, Sep. 1946, p. 411)

It has been shown that the ionization of the ionosphere is very closely associated with the number of sunspots visible. The number of sunspots varies greatly going through a marked cycle of roughly 11 years, and the ionization of the upper atmosphere follows this very closely. From this we

infer that the ultra-violet radiation sent out by the sun also varies in sympathy with the sunspot period, and the variation has been shown to be very large.

TERRESTRIAL MAGNETISM

It has long been known that the magnetic field of the earth undergoes a small regular change throughout the day. Thus if a sensitive compass needle in this country be carefully observed it will be seen to point a few minutes of arc to the east of magnetic north in the morning and a few minutes to the west in the afternoon. It is generally supposed that this regular diurnal change is due to electric currents flowing in the upper atmosphere, and that these currents are caused by tidal movements of the ionized air in the earth's permanent magnetic field. As the strength of the electric currents will depend on the amount of tidal movement (which will vary but little from day to day) and on the conductivity of the air, the amount of magnetic change through the day will vary with the sun's ultra-violet radiation. Long before the ionosphere was detected directly, it had been suggested that the upper air must be a conductor on account of these magnetic changes; and it had been observed that there was a remarkably close connection between the number of sunspots visible in any year and the average daily swing of the compass needle. This, of course, agrees exactly with the much more recent direct measurements of the ionization.

SOLAR "FLARES" OR FACULAE

From time to time small bright areas, lasting a relatively short time, are seen to occur on the sun. It seems that the ultra-violet radiation from these areas is increased far more than the visible radiation and a corresponding increase in the ionization of the upper atmosphere occurs. The increase in ionization is chiefly in the "D layer," where, owing to the relatively high density, of the air, ionization causes absorption rather than reflection of radio waves and a complete "blackout" of radio signals reflected by the upper ionosphere takes place. It is interesting that at these times the earth's magnetic field is also affected, and in such a way as would be accounted for if the tidal movements or the air were unchanged while the air suddenly became a much better conductor of electricity.

CORPUSCULAR RADIATION FROM THE SUN

The emission of charged particles by the sun causes both the aurora and large irregular variations of the earth's magnetic field. Such particles, though they travel fast by ordinary standards, travel much more slowly than light and probably take one to two days to reach us from the sun. The fact that they are charged is shown by their being deflected by the earth's magnetic field and made to strike the atmosphere in a circle around each magnetic pole. Besides ionizing the atmosphere and producing the aurora, in some way that is not at present entirely understood, these charged particles cause large irregular variations in the earth's magnetic field. While the magnetic variations are large compared to those produced by the regular tidal motion of the ionized atmosphere, they are not very great absolutely, and it is an exceptionally large magnetic disturbance in which the compass needle deviates as much as one degree in these islands.

Both magnetic disturbance and the aurora are closely associated with sunspots, years of many sunspots being also always years of much magnetic disturbance. Over shorter intervals of time the connection is not so close. A month in which there are, on the average, many sunspots is usually, but not always, a month with much magnetic disturbance; for shorter periods still the connection is less close. Often a particular magnetic disturbance can be associated with a particular sunspot, but this is by no means always the case.

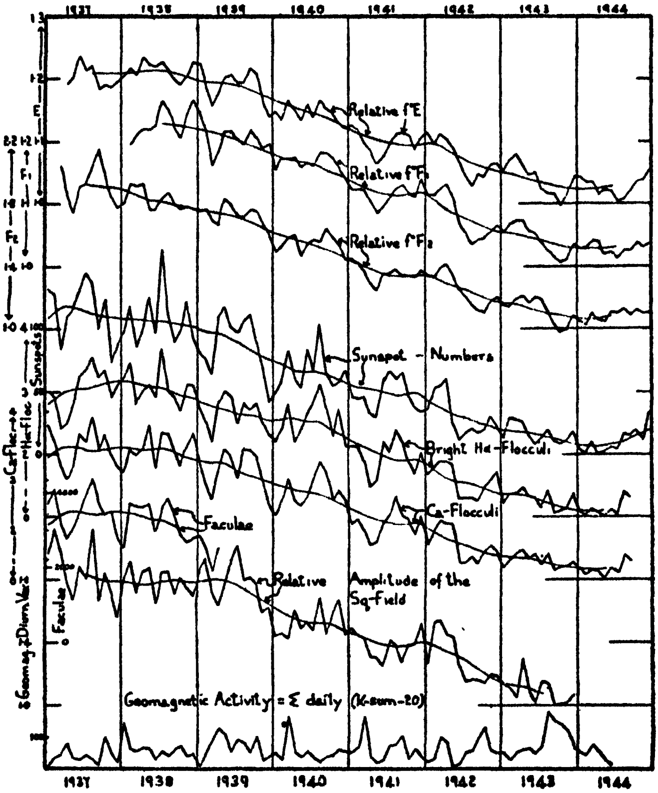


Fig. 4. Some interrelated solar and terrestrial phenomena (from the paper by C. W. Allen in *Terrestrial Magnetism and Atmospheric Electricity*, Mar. 1946, p. 1)

Since magnetic 'storms' appear to be associated with certain particular active areas on the sun, we might expect that 'storms' would tend to recur at intervals of about 27 days, this being the time taken by the sun to rotate on its axis relative to the earth at the latitude where most sunspots are found. This 27-day recurrence is indeed a fact, and there is a similar recurrence of the aurora.

RESUMÉ

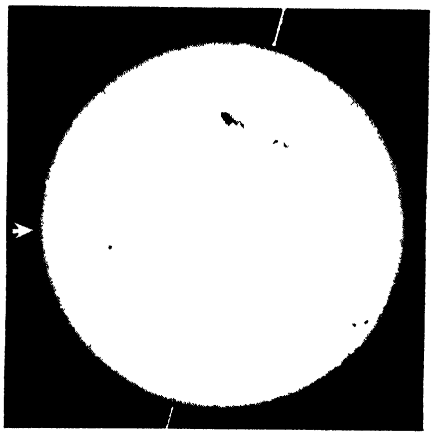
We thus see that there are many phenomena where conditions on the earth are very closely related to causes originating in the sun. These chiefly relate to the upper atmosphere; when we consider conditions much nearer the earth's surface such as ordinary weather, the connection becomes very slight and too small to be of use in any attempt to forecast the weather.

Exploration of the ionosphere (A) Typical record of heights of ion-densities obtained with automatic variable-frequency equipment at Kensington, Maryland, 3 p.m., May 15, 1936, (B) distribution of ions deduced from (A), (C) density of ionization deduced from (B) showing paths of waves of various frequencies Diagram (C) shows transmitter and receiver separated for simplification, although in actual work the radio transmitter and receiver are at same station and the wave paths are vertical.

[*A. G. McNish, Journal of Applied Physics, Vol 8, Nov 1937, p. 720*]

The sun, photographed in monochromatic light (Calcium, 3934A). The calcium clouds (flocculi) over sunspots are well shown.

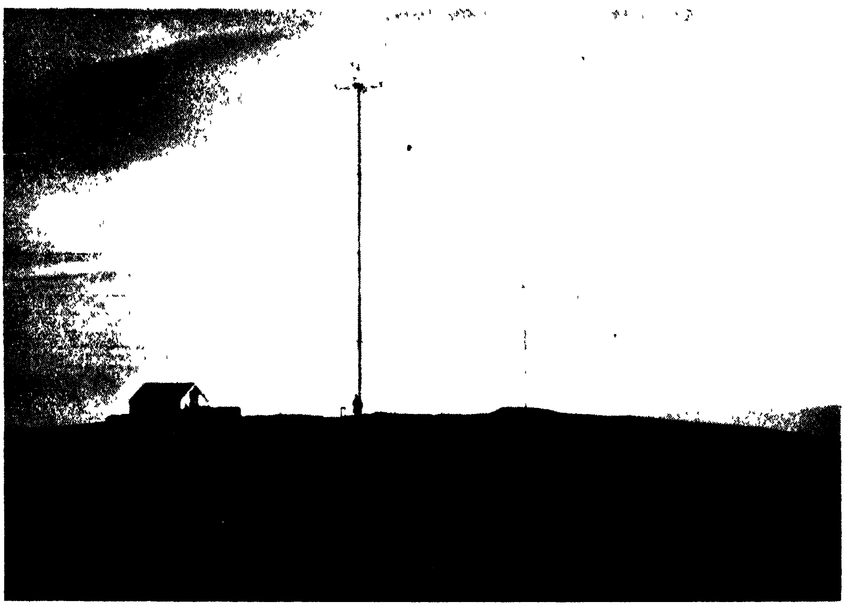
[*Dr. T. Royds, Kodaikanal Observatory, India*]



The sun, photographed in integrated light at Greenwich, Feb. 5, 1946, showing a giant group of sunspots. Patches of faculae are faintly visible near the edge of the sun, as indicated by the white arrow.

[*By courtesy of the Astronomer Royal*]

Hauling the equipment to the site



General view of Costa Head

PLATE II

AN ORKNEY WIND SURVEY

By A. H. Stodhart

No doubt most of us have seen, at some time or another, mounted on farm houses or on unstable looking poles, small propellors whistling round in the wind and driving correspondingly small electric generators which supply some form of lighting to the local homestead. In view of the demand in isolated districts for this type of windmill, the Electrical Research Association has for some time been studying their behaviour under various operating conditions, so that recommendations can be made for the most suitable design and method of use. When electricity supply authorities and Government departments began, some time ago, to take an interest in wind-power generation on a larger scale, the E.R.A. was therefore asked to assist in determining the practicability of such an undertaking.

One of the first essentials for the design of large aerogenerators is a knowledge of the wind conditions and of the potential energy available from the wind at the particular site on which the machine is to be erected. A study carried out with the assistance of the Air Ministry Meteorological Office of the wind distribution over the British Isles suggested that, amongst other places, Orkney was not without its fair share of wind. The North of Scotland Hydro-Electric Board, responsible for electricity generation and distribution in the northern districts were also interested in the project and thus arrangements were made, last summer, to carry out an initial wind survey on Orkney Mainland.

Certain American reports, especially those dealing with the design and construction of the 1250 kw aerogenerator at Grandpa's Knob, in Central Vermont, U S A , suggested that specially large increases in wind velocity might occur over the tops of hills of a certain shape. Since the power available from the wind is proportional to the cube of its velocity it is important to make the fullest use of such knowledge when selecting potential sites.

A close study of the contour map of Orkney Mainland showed several promising looking hills, but, of course, we were limited to some extent by other considerations, such as proximity to distribution lines and general accessibility. Two hills of widely contrasting shapes were eventually selected. The first, Costa Head, on the north-west coast of the island, is a ridge measuring slightly less than 500 feet to the summit, and about half a mile long, having steeply sloping sides and bounded on the north by a cliff face some 400 feet sheer to the sea The second, Vestra Fiold, lies half way down the west coast and is a gently sloping, flat-topped mound rising evenly from the sea to its summit, 420 ft. high at almost a mile inland.

A distant view of these hills conveyed an impression of complete barrenness, an opinion confirmed by closer inspection, their only vegetation consisting of close cropped heather and some short marshy growth. Having been advised by the Meteorological Office that, under these conditions, anemometer readings at a height of 10 feet above ground would be quite reliable, cup counter anemometers were erected at this height

On Costa Head, three anemometers were used, placed about 100 yards apart along the top of the ridge in a line running roughly North to South. This gave an opportunity to study, among other things, the effect of the 400-foot cliff face on the northerly winds. On Vestra Fiold only two anemometers were used, placed a little less than 100 yards apart on the flat top. A further instrument of the same type was mounted on a 30-foot pole at Bignold Park just outside Kirkwall, the site of a former climatological station ; a valuable comparison with past wind records was thus possible.

Observations of wind speed and direction were made hourly during the day at the hill sites in 1948 from July 10 to August 8. The results showed that the

sites we had selected were subject to considerably higher average winds than the Bignold Park station—in the case of Costa Head an increase of 50% in the mean wind speed was obtained—and that the steeply sloping hill did cause an increase in the wind speed at a height of 10 ft. It was also found that for a given wind direction, there appeared to be a fixed ratio of wind speed at Costa to that at Vestra. As the wind changed direction to flow over different relative slopes on the two hills, so the ratio of their mean wind speeds varied ; in other words, we had found, in Costa, a hill which had the accelerating effect upon the wind to which reference has already been made.

The next stage was to determine the height to which this increase was effective and at the same time to obtain information on the wind *régime* at greater heights, since the turbine hub of a large aerogenerator would have to be some 70 ft. or more above ground level. It was planned to use cup contact anemometers mounted at different heights on a light steel mast which could not be climbed and to allow the instruments to run with only periodical attention ; suitable recording apparatus had therefore to be devised and constructed to meet our particular requirements. The design was adapted from the wind gradient recorder now in use by the Meteorological Office at Rye. Telephone call counters, having cyclometer type dials, are operated electrically by the mercury switches in the cup anemometers to which they are connected. An electrically operated, remote reading, wind direction indicator is also used, the pointer being replaced by a dial marked at 5° intervals. An extra call counter is also fitted to act as a timing device The five counters and the wind directiom dial are mounted in a light-tight box where they are illuminated at half-hourly intervals, a time-switch being used to operate two lights. Twelve volt accumulators are used for electricity supply to the instrument and lamp circuits The time-switch also controls the timing counter through a relay. A prism, lens and camera complete the assembly ; the camera consists of two drums, one clockwork driven, the other freely moving, around which a length of bromide paper, sufficient to cover one week's readings, is wound. The paper moves past a shutter at the rate of 0.4″ per hour. While the light in the counter box is on, the counters remain stationary, and since the exposure time is only 5 or 6 seconds, no perceptible movement of the film occurs during exposure Having accumulated the necessary equipment, designed to be as light as was consistent with the necessary mechanical strength—though, even then, amply heavy enough for man handling over steep, rough moorland !—the next sortie to Orkney was carried out in mid-October, by a party of four.

On the assumption that it was better to tackle the more difficult hill first, the assistance of a nearby farmer and his tractor were solicited (see Plate II) and Operation Costa was set in motion. Protection from the elements being one of the essentials for physical well-being at this time of the year, the erection of a hut was given priority over other work for the first couple of days. An Orcadian carpenter prophesied gloomily that it would be at the bottom of the hill within a month. It was, however, firmly guyed down and staked and a wall of peat built round it and it still graces the top of Costa Hill. Digging holes for the guy anchor plates presented two slight snags ; first, the regrettable tendency of the water level—the ground was wet and peaty—to rise at a rate only slightly less than the rate of bailing maintained by the digger, and secondly, the increasing hardness of successive layers of rock. These were overcome eventually and the assembly of the sectional tubular steel mast was begun. It was at this stage that Orkney was subjected to one of its more severe gales and we soon discovered that under these conditions the terminal velocity of a hat being blown along a hill slope is considerably higher than that of its late wearer ! It was also learnt that, however rainproof they may be, it was not advisable to wear loose fitting gas capes unless it was desired to become airborne and to achieve an un-

stable state. Measurements taken at 5 ft. above ground from a hastily erected cup generator anemometer showed a maximum gust during the morning of 90 m.p.h. while at no time during the period of observation did it indicate a wind speed of less than 60 m.p.h. The next day normal operations were continued and by the beginning of November the mast assembly was complete. The arrangement of the instruments can be seen in Plate II. The cross arms at the top, i.e. at 70 ft., carry three cup contact anemometers and a cup generator anemometer with the wind direction indicator at their centre. Half way down the mast at 35 ft. two more arms carry cup contact anemometers. Duplication of instruments was necessary to cover any unserviceability since it would not be possible to climb the mast after erection. In addition to the main mast, a 10-foot pole mounting a cup contact anemometer was erected to provide readings comparable with those taken in the summer and to complete the information required concerning the vertical wind gradient. Finally, a thirty foot lattice tower, which is shown in Plate II, was erected to carry an anemometer of a type extensively used in France to measure the wind energy available. It con-consists of four hemispherical cups split horizontally across their diameter, separated, and joined by semi-cylinders some 18 in. long, thus providing greater torque without increase in peripheral speed. These cups drive a generator, whose output is proportional to the cube of the wind speed. This output is fed to an electric meter calibrated in kwh/sq. metre.

Erection of the mast, tower and pole was carried out without incident on a calm day, and the party returned to its headquarters that evening feeling satisfied with the progress made. This pleasure was short lived however, due, once more, to a gale " severe at times, in the sea area Fair Isle, etc.". The mast sections settled down more firmly due to the wind pressure on the guys which then started to bow and set up a troublesome oscillatory motion in the mast. This tended to upset the anemometers which began to shed cups in a most disconcerting fashion until, at 3 p.m. on the day following the erection, only two of them were still visibly serviceable Neither of these was able to supply any information on the wind speed, the vibration of the mast being such that the mercury in the cups was being shuttled back and forth at a rate which caused the counters to which they were electrically connected to make a noise resembling a two-stroke at peak revs. Readings taken from the anemometer mounted at 10ft., which was still operating successfully, showed a mean wind speed, between 11 00 and 11.15 hours of 72.4 m.p.h.

Two days later the mast was lowered to the accompaniment of a similar drop in morale. Steps were taken to insure against recurrence of the incident. The anemometer cups were brazed on more firmly, the top assembly was strengthened by additional members, and brackets were fitted at 15 and 45 feet up the mast to take additional guys. These improvements accomplished, the mast was then re-erected ; all guys were pulled tightly down, and fingers firmly crossed. Attention was then turned to the other site, at Vestra Fiold. This presented fewer difficulties and no major snags occurred during the assembly and erection. Accommodation for the recorder, and provision for indoor working was provided by a disused part-completed air raid shelter. It was somewhat cramped but in bad weather this difficulty was solved by taking it in turns to work outside.

The task being completed and arrangements made for weekly changing of the recorder films and replacement of batteries, the party turned not entirely unwilling faces southwards, arriving back in London on December 18. Nevertheless it retained the memory of excellent food and unfailing hospitality, of tremendous seas and of the once observed and unforgettable flash of green light as the sun slipped down behind the distant Scottish hills in the last stage of one of the many glorious sunsets.

METEOROLOGICAL INSTRUMENTS

AUTOMATIC WEATHER STATIONS

By C. A. Wood

Meteorologists have a well-earned reputation for hardiness, and, generally speaking, there is no place in the world to which they will not go in order to obtain information about the ways of the atmosphere : hot or cold, wet or dry, it is all the same to them. There are places, however, where even the meteorologist thinks it prudent to instal an automatic weather station—generally in remote areas where the supply problem for the staff of an ordinary station would be extremely difficult, or in tracts of ocean which are but infrequently crossed by shipping. For example, during the Second World War the Germans set up floating automatic weather stations in the Atlantic Ocean, and in the U.S.S.R. the automatic weather station has been put into service with success. An example of a floating automatic weather unit was described in *Weather*, Vol. 2, pp. 197–8, and now, through the kindness of the Bendix Aviation Corporation (Friez Instrument Division), Baltimore, Maryland, U.S.A., it is possible to give details of the progress which has been made in this field in America.

The development of automatic weather stations began in the U.S.A. in 1939, sponsored by the Bureau of Aeronautics of the U.S. Navy. The method was based on the system of measurement used in the audio-modulated-frequency radiosonde, and upon the successful demonstration of this method by the Radio Section of the National Bureau of Standards a complete station was built by the Friez Instrument Division for the Navy and placed in operation in the spring of 1941. Since that time various types and sizes of automatic stations have been constructed by different organizations in the United States, working in co-operation with governmental agencies. The Navy-type station, manufactured by the Bendix Aviation Corporation, is an excellent example of the automatic weather station art, and shows the remarkable ingenuity which must be exercised in the construction of such a station. Figure 1 shows the station as set up : the house containing the power plant, controls and transmitter is cubical in shape, interior dimensions six feet along each edge, and is of prefabricated construction on a concrete foundation. The walls are heavily insulated, as is the copper-covered roof. The instrument " screen " is mounted above the house and access is gained to it by means of a ladder. The complete house weighs approximately one ton, and is able to withstand high winds and severe climatic conditions. Thermostatically controlled ventilation cools the house in warm weather, and an elaborate system of shutters ensures that stale air is exhausted without the admission of undesirable elements like rain or snow, or even birds and small animals ! One can well imagine that such a pleasant haven would readily be invaded by creatures of the wild in an inhospitable climate.

THE MASTER CONTROL

The control of the station is centred in a programme unit which, through a clock, turns the station on and off according to a predetermined schedule, and shifts the transmission frequency for day and night operation. The clock is an

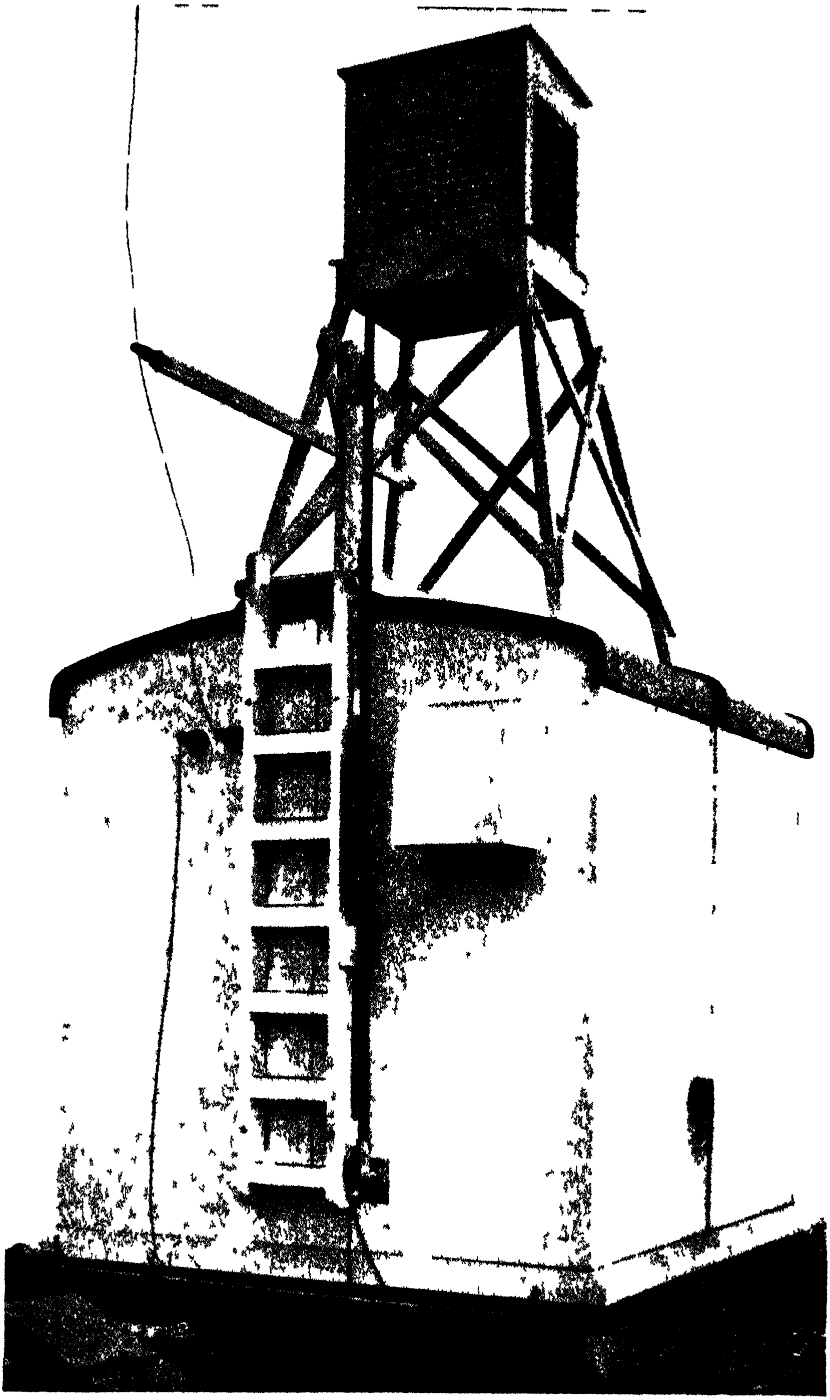


Fig. 1. The automatic weather station

International Business Machines model, weight-driven and automatically re-wound by an electric motor. The programme mechanism is mounted directly on the clock and is driven from a ratchet wheel on the minute-hand shaft. A large disc having 288 teeth is notched ahead, one tooth every five minutes, by means of the ratchet wheel, and this large disc turns once in 24 hours and has 96 holes around its periphery, in which contact-actuating pins are screwed. A programme can thus be set up so that the station will start at any quarter-hour. A cam, mounted on the main programme disc and composed of two overlapping sections, shifts the frequency for day and night operations. The clock is carefully protected from temperature changes, and graphs are provided to show the turns of the pendulum bob necessary to correct approximately for any other latitude than the one at which it is initially set on shipping (45° latitude and sea level).

THE POWER PLANT

Power for the installation is provided by a petrol-electric set (Onan Model 10LS) which can generate 1 kw. of 115 v. 60 c/s. A.C.; a D.C. exciter is used in the conventional manner for the field of the alternator. The engine is a one-cylinder, four-cycle model, air-cooled, and ignition is by means of a high-tension magneto built into the flywheel. There is an automatic choke, reported to be extremely reliable in starting. The 80-gallon fuel tank holds sufficient petrol for four months of operation in warm weather and for two months in very cold regions, where considerable heating is required. Thermostats control the temperature of the engine, to prevent fire or (in cold weather) difficulty in starting, and a thermal cut-out is employed to break the starting circuit in case the engine fails to start after a minute's cranking; this obviates "flattening" of the batteries. Adjacent to the power-plant is an automatic fire-extinguisher which, if the inside temperature rises so rapidly as to indicate a fire, fills the house with carbon dioxide and switches off the engine.

BAROMETRIC PRESSURE

The pressure unit (Figure 2) is a standard micro-barograph, but in place of the clock and chart cylinder there is an insulating bar with 100 contact buttons along it in two rows. Each button corresponds to one millibar, for a range of 100 mb.; the contacts are connected to a series of resistances chosen to give a linear pressure-frequency curve when used in connexion with a relaxation oscillator which controls the keying relay in the transmitter. The contact arm (what would normally be the pen-arm) "floats" freely without touching the buttons except at the time for the pressure measurement, when an electromagnetic device holds the arm against the buttons.

HUMIDITY

The humidity unit (Figure 3) is based on the standard hair hygrograph, and its operation is similar to that of the pressure unit except that it only has 50 contact buttons instead of 100.

TEMPERATURE

Temperature (Figure 3) is measured by means of four ceramic resistances in series, mounted in a circular louvred aluminium shield. The resistances have

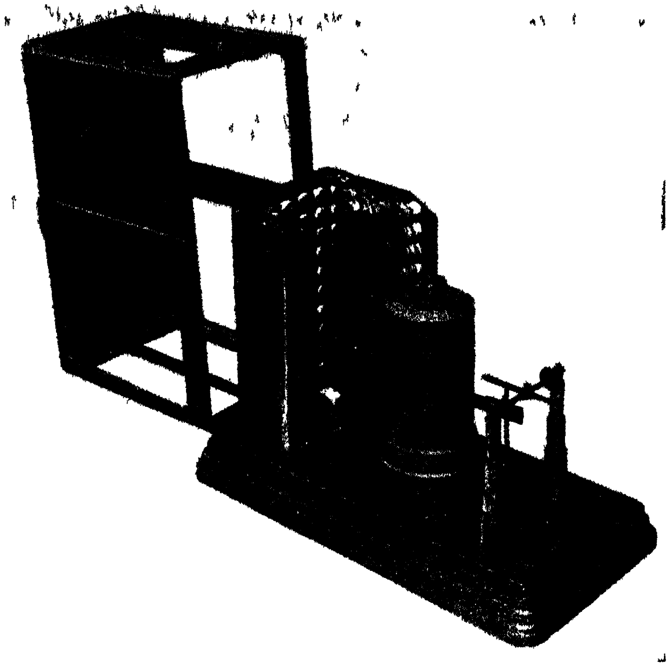


Fig 2 The Pressure Unit

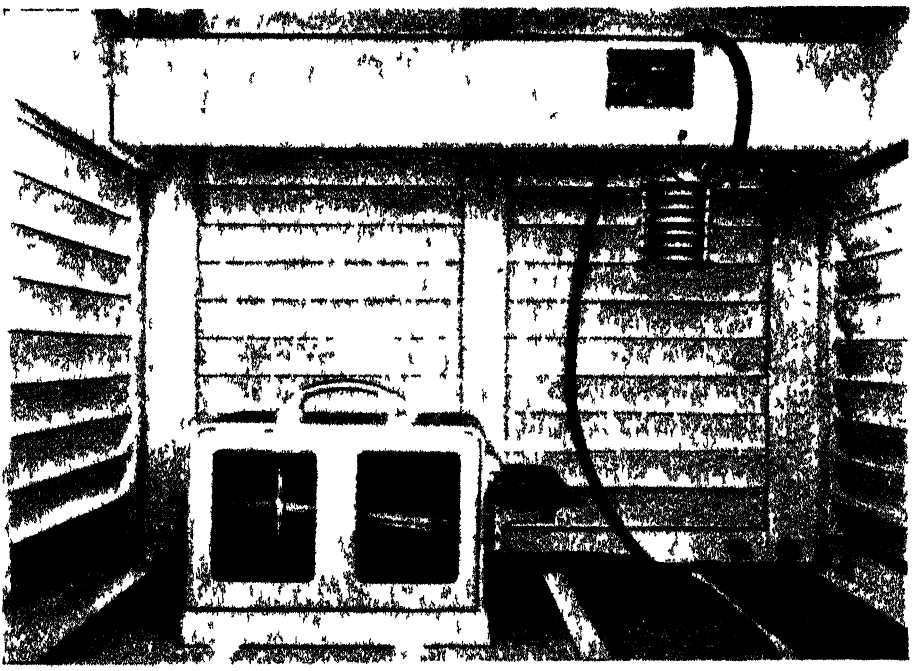


Fig 3 The temperature and humidity recorders

a large negative temperature coefficient and are similar to the ones used in radiosondes (see previous article in *Weather*, Vol. 2, p. 198).

WIND

The wind transmitter employs a three-cup anemometer concentrically mounted above a wind-vane, and a series of contactor buttons, cams and resistances are employed in a manner similar to the wind-direction and velocity units used in meteorological offices in this country, the difference being that instead of lighting a lamp on a direction indicator panel, or sounding a buzzer, the impulses are conveyed to the relaxation oscillator of the automatic weather station and thence to the transmitter, via an amplifier-tube relay.

RAINFALL

Rainfall is measured by an ordinary tipping-bucket gauge which through its contacts controls a coding mechanism that positions contact arms with respect to two sets of resistances, one for fractions of an inch and one for whole inches. The measurement accumulates to 12 inches and then repeats.

TRANSMITTING THE OBSERVATIONS

The selection and control of the measuring units are accomplished by a circuit selector which operates switches to close circuits for 5-second identification signals and 40-second signals from the meteorological instruments. G.E.C. synchronous inductor motors, having an armature speed of 100 r.p.m., are used to obtain accurate timing. The circuit selector keeps the station running long enough for two complete message sequences (approx. 13 minutes). The identification letters P, T, H, D, V, R and Q indicate the various weather elements being reported, the letter Q being included as there are two rainfall sequences to measure fractions and whole inches, as previously mentioned. In addition, there is a call-letter cam which takes 45 seconds for a turn and transmits the station call-letters three times.

The transmitter consists of a crystal oscillator coupled to a plate-modulated-power amplifier. The modulator is fed from a phase inverter coupled to the output of an audio oscillator having a frequency of approximately 800 c/s. The crystal oscillator employs a conventional electron-coupled circuit. The power output is in excess of 20 watts, but this can be increased if a larger transmitter is required for longer range working.

In order to receive and evaluate the data it is necessary to have a suitable receiver, a stop-watch and a set of calibration curves. The time required for an integral number of pulses is obtained with the stop-watch and the frequency can then be calculated. This frequency is subjected to a correction and the desired meteorological quantity is then obtained from the calibration curve. Calibration curves are furnished with each station, showing frequency plotted against the appropriate meteorological element: the curves for pressure and temperature are of course individual for each station, but the others are standard for all stations.

Louvan E. Wood, of the Friez Instrument Division, Bendix Aviation Corporation, Baltimore (from whose paper in the *Journal of Meteorology*, Vol. 3, No. 4, Dec. 1946 (U.S.A.), this brief description has been taken), makes the

following comment on automatic weather-stations :

" An automatic station compares favourably with a manned station in many respects. However, a skilled observer can, by looking at the sky, gain a comprehensive picture of the state of the weather ; to do so is impossible with the present automatic station. Perhaps this weakness will be eliminated . . . . the televising of the entire sky at an automatic station, so that a meteorologist at a central station may ' see ' the weather at the remote place is not beyond the realms of possibility."

THUNDERSTORM CENSUS ORGANIZATION

The British Thunderstorm Survey Section of the above organization have recently published a chart of the thunderstorms which occurred during the period May 14-16, 1949. The chart, which measures three feet square, and covers England and Wales, analyses the storms by indicating overhead areas, damage areas, and isochrones (where appropriate). A welcome addition to the meteorologist is a table of upper air soundings.

It is intended to publish a set of these charts during the year, and it is expected that there may be about thirty. The price is 6s. 0d. per copy.

Limitations of space prevent reproduction of the chart, but a copy has been placed in the library of the Royal Meteorological Society and may be consulted by those interested.

INSTRUMENTS, BOOKS, ETC., WANTED OR FOR SALE

WANTED

The Phenological Report 1944. Wanted to buy or borrow by E. P. Jeffree, Agricultural Dept., Marischal College, Aberdeen.

AIR MASSES OF THE SOUTHERN HEMISPHERE

By J. Gentilli, D.Sc. (Venice)
University of Western Australia

PART II

ZONAL AIR CIRCULATION

The study of the climatic properties of the hemisphere's surface shows that Australia is the chief source of dry air masses, with an area of dry climates well over 2,000,000 square miles[8]. The frequency and persistence of *Tropical continental* (*Tc*) air masses therefore is likely to be greater in Australia than in either Africa or America south of the equator. A contrasting feature of the hemisphere's surface is the enormous area below freezing point during 100 or more days, an area which may be estimated to cover about 18,000,000 square miles (Figure 5).

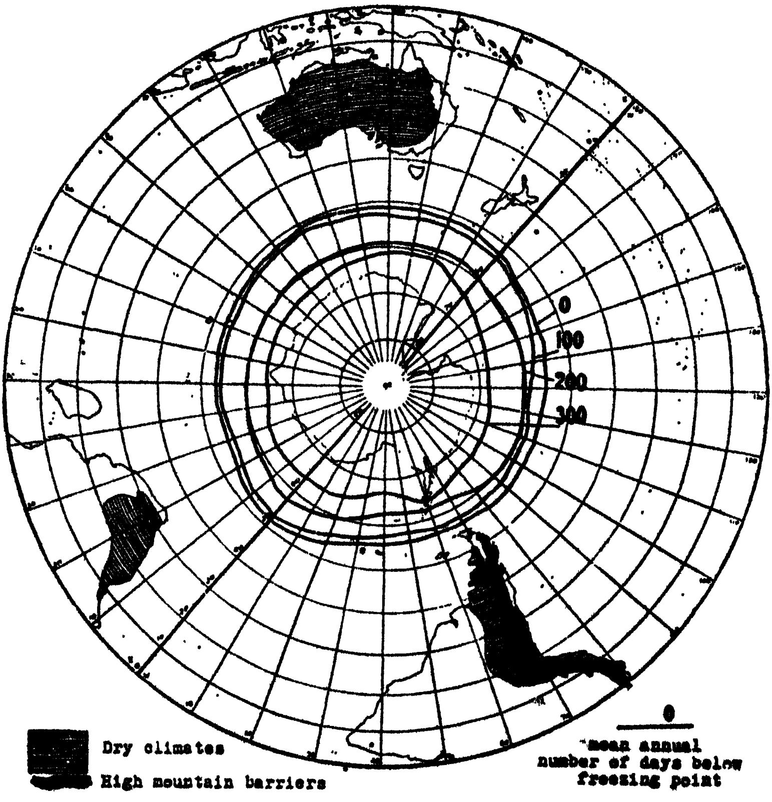


Fig. 5. Sources of dry air masses and cold air masses in Southern hemisphere

The absence of large continental masses between 40° S. and 60° S. permits an exceptionally strong belt of westerlies to develop. The measurement of the intensity of air circulation in this belt (zonal air circulation) can be attempted by using the circulation index evolved by the Massachusetts Institute of Technology[9], i.e. the drop in pressure between 35° and 55° of latitude. In the

Australian sector it is impossible to compute the index further than 43° S. because of the lack of records south of Tasmania; it is however possible to add a constant to the values found between 35° and 43° S. The constant is the average drop in pressure between 43° and 55° S. or about 10 millibars.

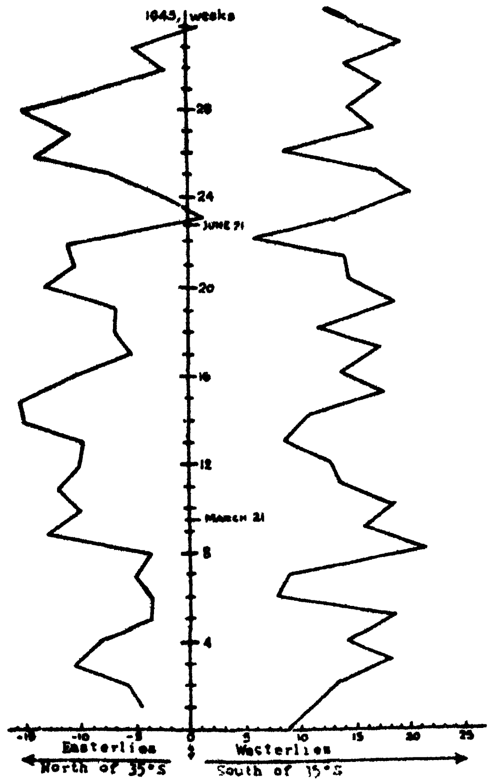


Fig. 6. Circulation index between 10° and 35°S (easterlies) and between 35° and 55°S. (westerlies, see text). The vertical column shows time in weeks from January 7 to August 25, 1945 (Sundays excepted, and early published data incomplete). The horizontal bar shows the intensity of circulation; the further to the left, the stronger the easterlies; the further to the right, the stronger the westerlies; zero corresponds to northerly or southerly winds

Thus the observed drop between 35° and 43° S. plus the constant (estimated drop) between 43° and 55° S. give an index very roughly comparable with the American one. The most striking result of this analysis is that no negative values—indicating an easterly circulation—were ever found. The minimum index, 6, still indicates marked westerlies; it was for the week ended June 16, 1945. A maximum index of 21, corresponding to a westerly gale, was computed for the week ended 10 March 1945. The average value for the first eight months of 1945 reached 16; this compares with a maximum of 15 and a minimum of –5 in North America during 1937 and part of 1938, while the North American average may be estimated at 4. If the mean pressure difference as shown by the index is nearly proportional to the mean wind

component, the Australian zonal circulation is about four times as strong as the North American zonal circulation (Figure 6).

In view of the fact that tropical air-circulation is of paramount importance in Australia, the Massachusetts index has been computed for the mean weekly pressure gradient between 10° and 35° S. The negative values thus obtained indicate a marked, at times very strong, easterly flow, with a maximum of −16 for the weeks ended April 28 and July 28, 1945, and a minimum of +1 (showing a very weak westerly flow) for the week ended June 23.

A general statement of the circulation in the hemisphere may be as follows. The airflow in the low-middle latitudes is affected by anticyclones, with their accompanying subsidence and divergence. The hemisphere's surface airflow in midwinter is controlled by very large planetary anticyclonic cells located between 20° and 35° S.; the Indian Ocean cell is outstanding in both size and intensity, while the corresponding Australian-winter high is much weaker. In

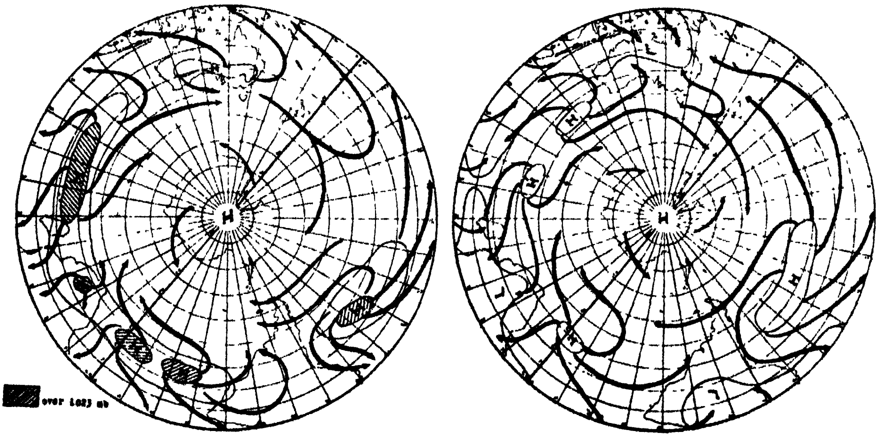


Fig. 7. Surface airflow over Southern hemisphere in midwinter (left) and midsummer (right)

midsummer, the planetary anticyclonic cells move southwards, being then located between 25° and 40° S.; the Indian Ocean cell may be split into two minor sections, and the Australian high disappears altogether, while a marked low forms over the northern area of the continent. Thus while the surface air-circulation of the Indian Ocean remains fundamentally the same, the Australian surface air-circulation is reversed (Figure 7).

A careful analysis of the climatic properties of the hemisphere's surface and of the airflow pattern leads to the location of the air-mass sources (Figure 8), from which air-mass movements and characteristics may easily be gathered.

AIR MASS SOURCES

The source of *Antarctic* (*A*) air varies in area between about 8,000,000 square miles in summer and 11,000,000 in winter. The source of *Polar maritime* (*Pm*) air is an enormous ring, which in winter may be estimated to cover over 30,000,000 square miles between 34° and 65° S. and in summer shrinks to

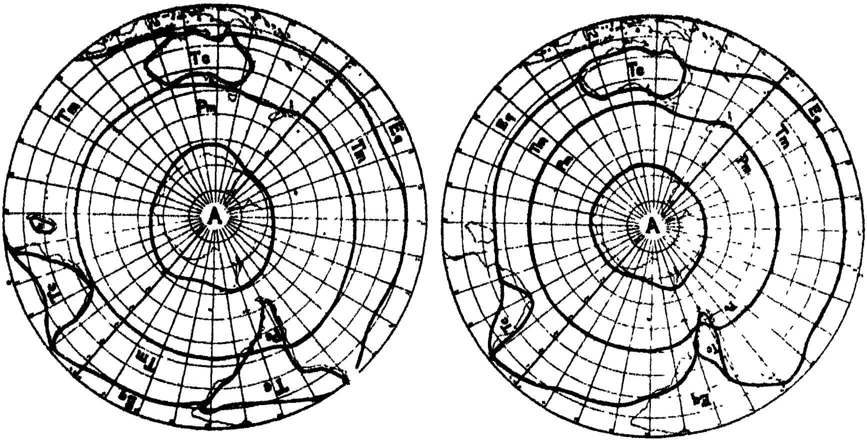


Fig. 8. Southern hemisphere air-mass sources in winter (left) and summer (right).

less than 20,000,000 square miles between 40° and 68° S. The source of *Tropical maritime* (*Tm*) air is an area of comparable size, about 31,000,000 square miles in winter and 34,000,000 in summer, when a southward advance of *Equatorial* (*Eq*) air over the Indian Ocean greatly reduces its area. Because of the Asiatic monsoon, *Tm* air extends northwards beyond the equator over the northern Indian Ocean in winter ; the reversal of the monsoonal flow in summer pushes *Eq* air southwards as mentioned. *Equatorial* (*Eq*) air itself is little known ; the area of its source in the southern hemisphere may be set at 16,000,000 square miles in winter (when it is absent from the Indian Ocean) and 34,000,000 in summer (when it reaches as far as 24° S. over the same ocean).

Tropical continental (*Tc*) air comes from part of each of the three southern continents, and because of its latitude and shape Australia is the most typical source of *Tc* air masses in the hemisphere. A most important aspect of seasonal changes is the persistent control of Australia's interior by *Tc* air masses in

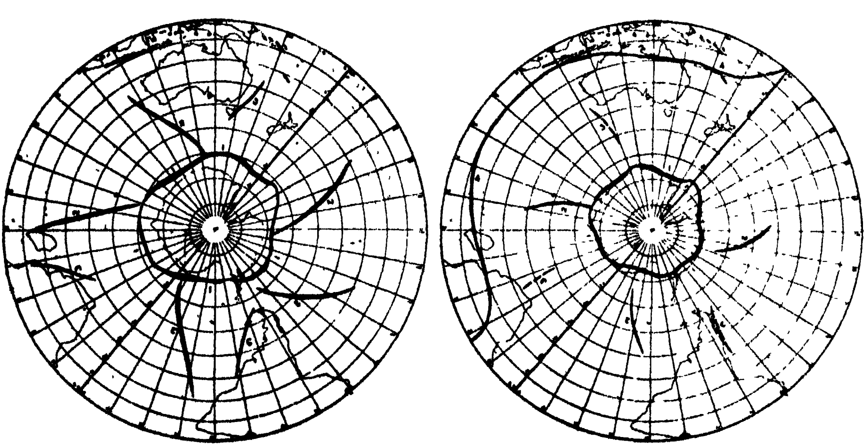


Fig. 9. Frontal zones in Southern Hemisphere in winter (left) and summer (right) 1—Antarctic ; 2—Cell subpolar ; 3—Epicontinental subpolar ; 4—Intertropical

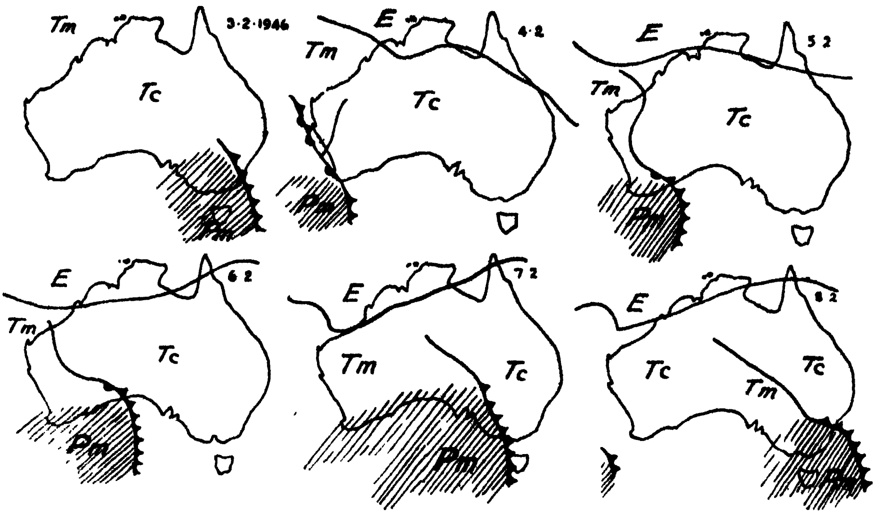


Fig. 10. Summer air masses

both summer and winter, while large areas in Africa and South America are taken over by *Eq* masses in summer, with a consequent great increase in their humidity. *Polar continental* (*Pc*) air may only occur in South America, and is not likely to be typical because of the limited area of its source there.

The great development of planetary anticyclonic cells in the hemisphere leads to a frequent descent of *Superior* (*S*) air masses which tend to merge into *Tc*.

Extensive frontogenesis is found along the steeper temperature gradients near the southwestern edge of each cell (Figure 9). The source of the great semi-occluded and at times multiple Australian winter fronts is found south-

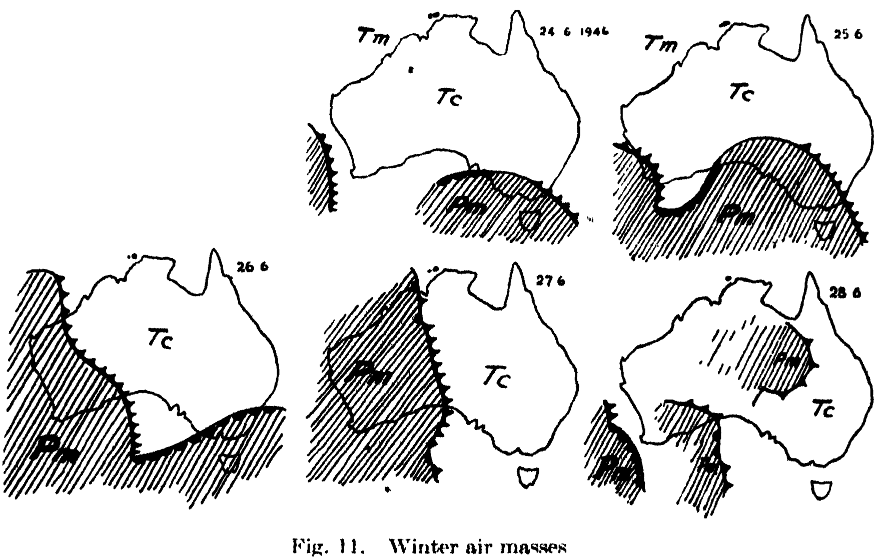


Fig. 11. Winter air masses

east of Madagascar, but it is likely that the anticyclonic circulation of the Australian winter high provides additional fronts to the south-west of Australia. The distance from the main source of winter fronts explains why so many of these fronts are partially or totally occluded by the time they reach the Western Australian shore[10]. Minor fronts due to the gradient between *Tc* and *Tm* masses in winter may occur to the south-east of Australia, but they cannot be important because this gradient is never very steep.

While the air-mass positions given above are generalized, it must be expected that actual masses and fronts will vary considerably. Two remarkable situations observed during 1946 have been outlined in Figures 10 and 11. The air masses have been shown, but it is clear that only very weak and usually not pluviogenetic fronts occur between *Tm* and *Tc* masses ; on the other hand, well-developed fronts are found between *Pm* and *Tm*, and the best fronts develop between *Pm* and *Tc*, the reason of course being that *Tm* and *Tc* often differ from each other in humidity rather than in temperature, *Pm* and *Tm* differ in temperature rather than in humidity, and *Pm* and *Tc* differ greatly in both temperature and humidity. While most European fronts occur after a clash of *Pc* and *Tm* masses, most fronts in the southern hemisphere are due to a clash of *Pm* and *Tc*, a difference which may explain some of the not yet understood aspects of frontal behaviour in the southern hemisphere.

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9. ALLEN, R. A. : *et al.*, Massachusetts Institute of Technology, *Phys. Oceanogr. and Met. Papers*, vol. 8, no. 3, 1940.

10. PALMER, C. E. : *Synoptic Analysis over the Southern Oceans*, Wellington 1942.

Part I of this article appeared in *Weather*, August 1949.

CHRISTMAS CARDS

The Society is arranging to print Christmas Cards for the convenience of Fellows, which will be available at 4s for six (minimum order) or 7s. 6d per dozen. The cards will be similar to those printed last year, except that the wording will be in brown and the photograph will be " Wind effects on snow in a railway cutting near Barras, Westmorland on 19 February 1947 " (by courtesy of British Railways). Orders should be sent to the Assistant Secretary at the Society's offices, enclosing a cheque or crossed postal order for the appropriate amount. Envelopes should be marked " Christmas Cards "

O'ER WHICH THEY FLEW*

By R. H. Douglas

"O, never vales to mortal view
Appeared like those o'er which they flew,
That land to human spirits given,
The lowermost vales of the storied heaven;"
—from *Kilkeny;* James Hogg.

The occasions are all too few, I fear, when the meteorologist is able to view the clouds from the vantage point of an aircraft in flight. The " land-locked " forecaster is apt to interpret cloud-forms in terms of what he sees from the ground, of what he remembers of the Cloud Atlas, or even of his impressions of the positive area on a tephigram ! These impressions are duly transferred to the cross-section-of-the-flight forecast, which is a cold scientific document and which allows for no speculation as to the attendant beauties of the cloud-forms.

The airline pilot, of course, has a much more intimate and three-dimensional viewpoint of the clouds, for so much of his time is spent in flying over, through, and around the cloud-masses. Few pilots, however, in reporting a flight, describe the clouds in anything but the most dry, laconic, and even profane terms !

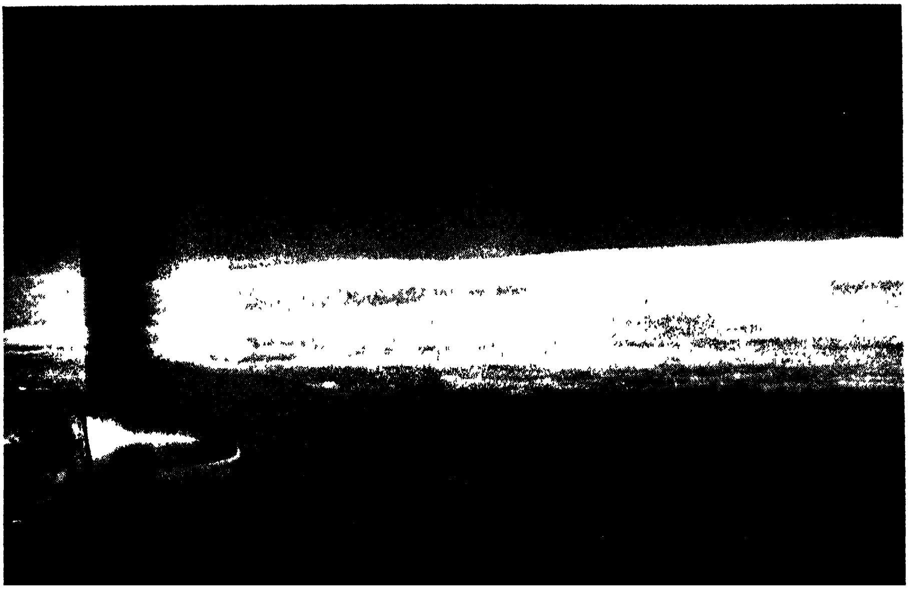
How well I remember the one and only occasion when a pilot, newly arrived at Gander from Prestwick, gave a truly inspired report of an occlusion, encountered several hundred miles off the Irish coast at sunset. I was extremely interested in this occlusion, and pressed him for a report of its characteristics and activity. The captain had the soul of a poet, and treated me to a detailed and artistic description of the tints and hues of the cloud-layers, glowing ruddily in the setting sun. To me, the purple line on my map became a living thing of beauty, thanks to a pilot who had eyes for more than his instrument panel.

My own experiences in flight have been somewhat barren of artistic delight. A grey undercast of stratus is hardly a thing of beauty, nor is an interminable flight through the drab sheets of cloud and rain of a warm front. So it was with a great deal of pleasant anticipation that I boarded an aircraft of Trans-Canada Airlines, on the morning of 15 May, 1948, bound for Bermuda on a familiarization flight.

The synoptic situation that morning promised an interesting flight (see Fig. 1). In particular, I was looking forward to an aerial view of the cold front which lay across the track, and, having a keen interest in photography, I was fully-armed with camera, film, and a red filter, determined to bring back a complete photographic record of the cloud formations encountered in flight.

Off the field at 1606 GMT, we climbed to twelve thousand feet and headed for Boston. Skies were grey after last night's storm, now centered over the Nova Scotia coast. Above was a drab veil of cirrostratus, and beneath us the undercast broke occasionally to reveal fleeting patches of countryside. At Boston, ascent was made to seventeen thousand feet, and just off the coast the high cloud vanished, leaving us bathed in brilliant noontime sunshine.

* By permission of the Controller of the Meteorological Service of Canada.



A. Looking south-east from position A. Note the densest cloud formation to the right of centre

B. Looking south-west from position B

PLATE III THE COLD FRONT

A In the squall line

B. The squall line from the south, position C

PLATE IV

THE SQUALL LINE

By 1800 GMT the cold front was visible, some 250 miles ahead. From northeast to southwest extended an unbroken band of towering cloud lying along the edge of the advancing cold air. The grey bases seemed almost to rest upon the sea, while dazzling white tops stood hard and firm against the blue sky.

Ahead, the clouds towered to flight level ; to the south-west, tops appeared to be somewhat lower. The highest and densest part of the front was to the south-east. Plate III A shows the view to the south-east, seen from position A

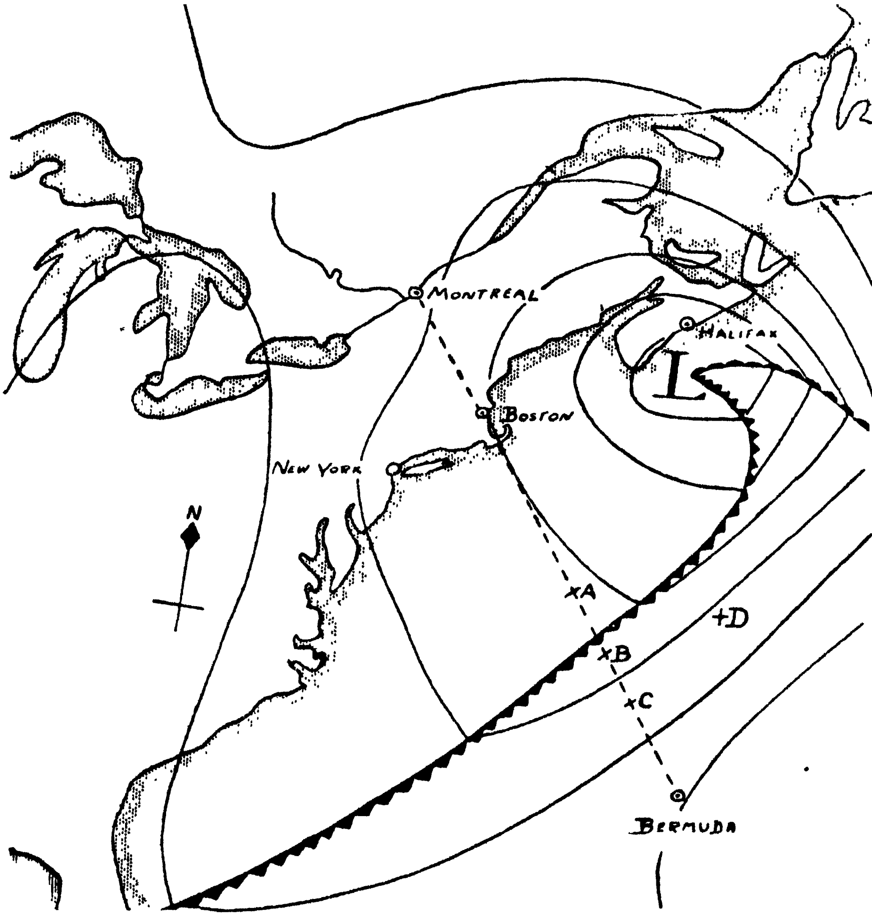


Fig. 1. Synoptic situation, May 15

(see Fig. 1). The thickest cloud formation of the entire front is plainly visible. Although over most of the front there was a thin veil of cirrostratus, over this portion, and conspicuous in the picture, the veil had thickened to a dense sheet of cloud. An hour later our aircraft skimmed over the tops of the frontal cloud-bank, while, to port, a dazzling white column of cumulonimbus loomed far above.

Now we had the most spectacular view of the front, looking south-west from position B and shown in Plate III B. Far to the south-west a long unbroken and clearly-marked band of cloud stretched below us. So sharp was the leading

edge, so perfect the unbroken curve of cloud, that I could almost see a smoothly-drawn blue line following the arc ! Here, in dramatic three-dimensional relief, stood the evidence of the freely-drawn curve on the weather-map, the cold front itself. The tops rose hard and firm, their near sides shadowed ; the bases were lost in the gloom of haze and shadow that covered the sea. The entire effect was as majestic as only nature can achieve.

This striking spectacle was barely astern when another view presented itself ahead. A short distance away, another wall of cloud loomed, compared to which the front itself seemed a mere picket-fence ! Here was a treat indeed —not only a fine specimen of a cold front, but a first-class squall line as well. More wondrous sky-scapes awaited the lens.

This was literally a wall—an unbroken mass of heavy cumulus and cumulonimbus, of which the cliff-like sides were vertical and the anvil-tops flattened far above. As our aircraft approached, a small gap appeared dead ahead—a narrow canyon—over which the anvils merged to form a roof. Into this gloomy tunnel we flew (Plate IVA) and a moment later emerged into the brilliant sunshine on the other side.

The view of the squall line from the south side was awe inspiring (Plate IVB, taken from position C). On the north side, the cloud had risen vertically, but on the south side the tops were overhanging. The grey sides were streaked with virga. In the foreground, slim castellated towers of altocumulus reached up below us. A slight haze hung over the sea, for we were now well within the warm airmass.

With regret, we watched this spectacular formation fade into the distance astern, and an hour later we landed at Kindley Field, Bermuda.

During the small hours of the following morning the squall line, its vigour sadly depleted, moved past Bermuda, and a few hours later the cold front brought rain to the island. Sleeping soundly, I missed a golden opportunity to view from the ground those very clouds over which we had flown a few hours earlier.

An examination of the synoptic charts, made upon my return to Montreal, revealed an active wave development on the cold front at 0030 GMT of the sixteenth, just six hours after the view shown in Plate III was photographed. The position was about thirty-seven degrees north, sixty-three degrees west (D in Fig. 1), and was confirmed by a surface vessel at that time. This wave continued to develop, and took its place with others in the central North Atlantic. — Now I speculate. It appears possible, by " backcasting ", that the solid mass of cloud, so conspicuous in Plate IIIA, was associated with this wave during the hours of its birth. Is Plate IIIA then the photograph of the birth of that storm, of the first successful counter attack of the warm air against the cold ? Perhaps the picture is simply of one or more well-developed cumulonimbus, concentrated at that particular spot on the front. But I like to think that the most apt title for the plate would be " Birth of a Storm ".

THE WEATHER OF AUGUST 1949

WARM, SUNNY AND DRY

August, like July, provided almost perfect holiday weather. There was more sunshine and considerably less rain than in the average month except for a relatively small area in Northern Scotland and Ireland. Britain's water supply position is steadily deteriorating ; in parts of the Isle of Wight domestic water is unpleasantly brackish. Figures available for the months June to August show it to have been an outstanding summer. At Kew Observatory there have been only two drier summers since rainfall records began there in 1871, while at Ross-on-Wye the summer rainfall total of 1·46 in. was the lowest on record. Most places in the south and west of England and Wales received more than 100 hours of sunshine in excess of the summer average ; at Kew it was the sunniest summer since 1933, and one of the six warmest over the past 80 years.

At the beginning of the month an unsettled westerly type of weather prevailed ; rain fell everywhere, and the worst gales since winter blew in the Strait of Dover on 2nd. For the next five days pressure remained low to the north-west of Scotland ; strong winds, cloud and some frontal rain were general in that region, while elsewhere weather was fair. A vigorous depression moved north-eastwards across Southern Ireland on 7th and 8th causing gales and fairly heavy rainfall over much of the country apart from the south and east. On 12th a long fair period began, other than in the extreme north, owing to the dominance of an anticyclone centred initially to the south-west of Ireland ; apart from some thundery rain around 22nd and 23rd, dry weather was general until 29th when the anticyclone began to recede slowly and a spell of unsettled south-westerly type of weather became established. The average temperature for the month was generally between 2° and 3·5° F above normal, and maxima exceeding 80° F were reported over much of England and Wales, notably on 14th, 15th and 22nd.

New Yorkers continued to suffer sweltering heat at least until 9th, when the thermomenter reached nearly 98° F, the hottest day ever recorded, while from Spain, France and Italy came similar reports of unusually high temperatures. By the middle of the month, however, torrential rain had caused floods in Italy and Austria and the level of the Danube near Vienna rose 18 ft in 36 hours. In New South Wales, along the Macleay River near Kempsey, several persons have been drowned, over 2,000 people rendered homeless, and many thousands of cattle lost because of widespread flooding.

	TEMPERATURE (°F)				RAIN (mm)*			SUNSHINE (hr)		
	Long period Average Max.	Long period Average Min.	This month Extreme Max.	This month Extreme Min.	Month	Diff. from Av.	Last 12 months	Month	Diff. from Av.	Last 12 months
Kew Obsy.	70·5	55·0	83	47	37	—23	418	223	+40	1754
Gorleston	68·0	55·0	82	49	17	—46	328	220	+23	1734
Birmingham	67·7	52·9	80	46	53	—16	650	180	+17	1513
Falmouth	66·1	55·1	†74	†50	32	—51	761	247	+51	1970
Valentia	63·1	54·5	75	48	125	+ 9	1317	151	+ 3	1338
Aldergrove	65·1	51·3	75	43	69	—28	754	112	—25	1323
Holyhead	63·0	55·1	81	44	53	—28	664	193	+22	1735
Tynemouth	63·8	53·1	76	47	40	—30	393			
Renfrew	64·3	50·0	75	43	106	—14	1104	156	+27	1443
Aberdeen	62·9	48·4	71	41	113	+38	684	128	—20	1581
Stornoway	60·3	50·0	69	44	82	—20	1236	114	—14	1264

* 25 mm = 1 inch (approx.) † The Lizard C.R.B.

LETTERS TO THE EDITORS

Luminous Clouds

It may be of interest to readers that during the night of 10-11 July 1949 luminous clouds were observed in the northern sky at Prestwick.

I was unfortunate myself in missing the display, but a colleague of mine was able to give me some details. It appeared that the clouds became visible at about 2330 GMT on the northern horizon and were similar to streaky patches of cirrus and most brilliantly lit up. At 0020 GMT the cloud had increased slightly in the form of a few bands orientated north-south, and then gradually a small patch of cloud appeared lying at right angles to the other cloud, *i.e.* running east-west." His final comments at 0050 GMT were, "as the cloud appeared it took on a most marked luminous glow."

Prestwick seems to have been one of the few stations in Scotland which observed the display—the Western Isles, for instance, were shrouded in low cloud, rain and drizzle, associated with a warm front, which at 0001 GMT on the 11th was lying over the north-western seaboard of Scotland. Parts of the north-east of the country were covered with cloud, but I understand that the luminous cloud was clearly discernible at both Abernethy and Blairgowrie.

Prestwick Airport — IAN H. DOBINSON

Periods in Thunderstorms and Rainfalls on the Island of Samos

Samos is a beautiful island of the Aegean Archipelago. Its surface is rugged and mountainous, covered with evergreen trees. It is situated between latitudes 37° 39′ and 37° 48′ N and longitudes 26° 24′ to 27° 06′ E.

Port Vathy, around which the capital town, of similar name, is built, is one of the largest natural ports of Greece and is situated in mean latitude 37° 45′ N and longitude 27° 00′ E. The climate is temperate, the maximum temperature observed at Vathy on 20 and 21 June 1942, was +40° C (104° F) and the minimum on the 5 and 6 February 1907, was −4° C (25° F). The mean rainfall is 950 mm annually (28in. approx.) and the prevailing wind is NW.

Having studied the weather changes for several years, I have come to the conclusion, by means of calculation and data from past records, that strong atmospheric phenomena such as thunderstorms and heavy rainfalls, repeat themselves with an increasing or decreasing intensity in 173 days. This period has remained constant during a cycle of at least 45 years, according to old records and fairly recent observations. It applies equally to earthquakes when the subterranean forces are in action.

In 1939, when testing this period for the first time, I forecast several thunderstorms and heavy rainfalls with accurate results. I received the congratulations of my scientific friends for my effort. I then started to investigate longer or shorter periods and found that half of the above period, *i.e.* 86·5 days was also useful in forecasting long-range weather conditions. This shorter period is 1/47th of the mean sun-spot cycle of 11 years and 47 days. By addition of the two above-mentioned periods, a new one of 259·5 days evolves and this period maintains a number of unchanged phases as well. The shortest period, which I discovered later consists of 21·6 days.

This period appears to be the effects of solar-constant sequences on the weather. If this theory is correct it holds out great hopes for the possibility of long-range weather forecasting all over the world. All the previously-mentioned periods are multiples of the last-mentioned and are not so obvious in summer as during the other seasons.

At some future date I shall show some other peculiarities in detail, which will be supplemented and supported by graphs. For the present, I beg any reader interested in the matter, to test the periods and inform me whether they are of any use in long-range weather forecasting in their respective countries.

1, Mandrocleous Street,
Vathy, Samos, Greece — N. S. RAPTOU

Drought in the Isle of Wight

So far the current year has given a record allowance of sunshine and drought in the Isle of Wight. The months of January and February both over-topped the 100 hour mark—proving the sunniest on our books. Never before have both these months exceeded 100 hours in the same year. This record was also repeated by June and July which, for the first time, both exceeded 300 hours in the same year, though neither month constituted an individual sunshine record. The sunshine for the first seven months of 1949 amounts to the respectable figure of 1,523·6 hours at Shanklin—considerably higher than anything known before in a register kept since 1907.

At Sandown, no rain fell between June 7th and July 14th (38 days) and only 0·04 in. found its way into the thirsty gauge from June 7th to July 29th (53 days), both absolute records since rainfall figures were first logged in 1906. In 1893, no rain at all was measured at Totland Bay in West Wight for 43 spring days, but no available records then existed for Sandown-Shanklin. At Sandown the present year has only produced 6·49 in. of rain on 45 days—both low records !

Except for December, 1948, when there was a slight excess, every month from Sept., 1948, until July, 1949, has given a deficiency of precipitation, amounting to the large total of 13·36 in. The state of the countryside after such a dry spell can be imagined—flowers and leaves withering and dying in the gardens which have become as brown as a hare's back ! Some ponds in the Island have dried up for the first time in living memory. It remains to be seen what the rest of this *annus mirabilis* will do. August is doing its best to create another sun record !

London, S.W.10 J. E. Cowper

Everybody's Weather Book

Will you kindly give me the customary courtesy of your columns to make a brief comment on your reviewer's criticisms of my recent book, as above.

Authors expect criticism from reviewers, and—as an author of some 15 books, I have always welcomed constructive criticism—but we do not expect a reviewer to misquote us. Your reviewer quotes me as saying on one page that the temperature of the sun is estimated to be 70 million ° F, and on another page 6,000° C. As he quoted the page numbers, I turned back to these with some surprise, and—as I imagined—found he had not read the paragraphs concerned with care. The latter temperature was quite clearly stated as being the *opinion of Newton* concerning the temperature of *sunspots*, and I wrote: "Newton suggested . . . the gases rising and flowing outwards at photospheric levels are cooled by expansion to about 4,000 deg. Cent., the photosphere being at a temperature of about 6,000 deg. Cent." Again, on the debatable matter of auroral sounds, I made no hard and fast statement, but merely gave to the reader the data collected from 184 observers in northern Canada by the Dominion Astrophysical Observatory at Victoria, B.C. Your reviewer is quite entitled to be sarcastic about such data, if he feels that way, but he should not imply that the data which I place before the reader are my own opinions.

I have had occasion to review many books myself, and to read many hundreds during my 30 years of authorship, but this seems to be the perfect example of how not to do it.

London R. M. Lester

Our reviewer replies : I am sorry that Mr. Lester should be under the impression that I had not read his book carefully and that I had misquoted him. In my review I stated that three different values were given in the book for the *surface* temperature of the sun, and I see no reason to modify this statement. What surprises me is that the author should seek to defend himself by saying that the correct figure of 6,000 degrees Centigrade was " stated as being the opinion of Newton " (Mr. H. W. Newton, of the Royal Observatory, Greenwich)—presumably the author's own opinion is that the sun's surface temperature is 70,000,000 degrees Fahrenheit ! He offers no excuse for the third alternative of 12,000 degrees (degrees Lester ?). I find it difficult to believe that many reliable observers in northern Canada have heard the aurora in mid-summer ; in those latitudes it is so light even at midnight in mid-summer that it must be difficult to see the aurora, let alone to hear it. Surely one of the primary duties of the author of a popular book is to anticipate such obvious queries as this when giving data from other publications, although in this case it was not clear that the statement did come from some other source.—Editors.

Whirlwind on the Thames

The letter from Mr. L. M. Leakey in your July number reminds me of the dust devil I saw on the hot sunny afternoon of Sunday, July 3. I was first made aware of it by a cloud of dust on the towpath on the south bank of the Thames, just above East Molesey lock. It then crossed the channel leading to the lock, creating a very obvious travelling whirlwind which caught amidships a small rowing boat which it turned through almost 90° in an anti-clockwise direction. The rower was amusingly unaware of what had upset his oarsmanship.

Through looking at the rowing boat I missed following the next move of the whirlwind, but became aware of a jacket some twenty feet in the air above the hatchway leading to the lower channel. The disturbance appeared to die out while crossing the latter.

London, W.1 F. H. W. Green

The "End" of the Ice Age

Mr. J. E. Ord is quite correct (August *Weather*, p. 268) in stating that the date quoted by Scandinavian geologists for the " end " of the Ice Age is 6,500 B.C., or roughly 8,500 years ago, but too much importance has been given to this figure, which is an estimate of the date of a purely local event—the splitting of the remains of the Scandinavian ice-sheet into two portions. By that time the climate of most of Europe and probably also North America had been temperate for some thousands of years.

It is optimistic to speak of the end of the " Ice Age". There have been a number of advances and retreats of the ice-sheets and glaciers during the past million years or so, the latest of which is generally known as the Würm in Europe and the Wisconsin in North America. This appears to be over, but it may not be the last of the series ; we may be living in an " interglacial " period. The end of the latest glacial episode was not a definite point of time, but was a gradual affair which progressed from the margins of the ice-sheets towards their centres. At any one place it may be considered to have arrived when the ice-sheet had retreated so far away that the country was free, not only of ice, but of the climate of the ice-border. In the marginal areas the " end " was some 20,000 years ago ; in Scandinavia and eastern Canada it was much later ; in Greenland and Antarctica it has not yet arrived.

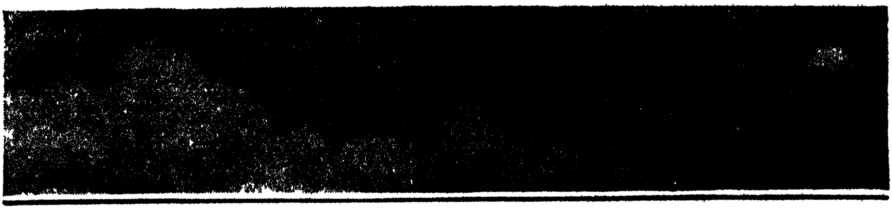
Ferring, Sussex — C. E. P. BROOKS

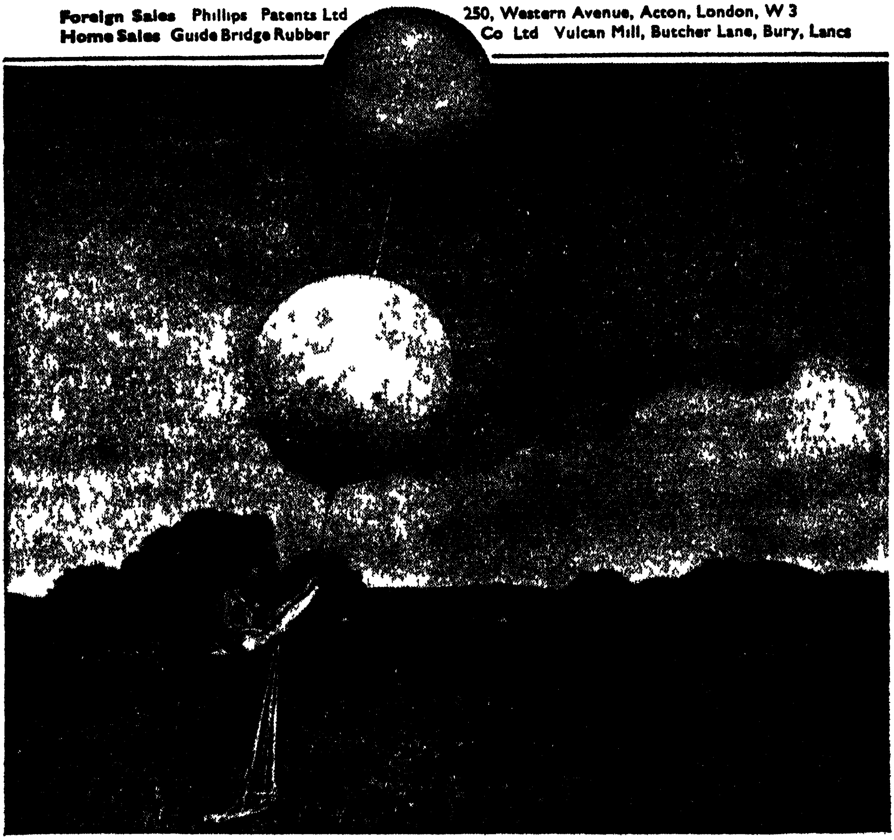
Halo Phenomena at Greenwich

The following unusual halo phenomena were observed here on 20 July 1949 :—A complete horizontal circle or mock sun ring, visible except near the sun, together with a brilliantly coloured 22° halo and parhelia. All phenomena were first observed at 1015 GMT and approximate measures taken about 1020 GMT gave the diameter of the horizontal circle as 73°, and the angular distance of the parhelia from the sun's centre as 30°. Also, from 1100 GMT an upper arc of contact to the 22° halo was seen. The horizontal ring and parhelia faded at 1105 GMT and the 22° halo became obscured by lower cloud at 1130 GMT.

Royal Observatory,
Greenwich

G. F. WELLS
B. R. LEATON





OCTOBER 1949

WEATHER

Vol. IV No. 10

CONTENTS

EDITORIAL

The reputation of meteorology as a science suffers because its imperfections are brought to public notice by the shortcomings of the weather forecast. Yet the basic physical explanations of nearly all weather phenomena are known ; we understand why, after a clear dawn, cumulus clouds build upward on some days and not on others, and how their growth may be limited by warm air aloft, although we cannot yet say at what stage the cloud droplets will coalesce into rain ; the outline of our knowledge is clear, but the detail needs to be filled in by research.

It is, perhaps, because the controversial aspects of weather have received more publicity than its established results, that meteorology has formed so small a part of the elementary science taught in schools. Physics and chemistry have the advantages of easily repeatable experiment, but they introduce the young student to an unfamiliar world of test-tubes and solutions ; meteorology, on the other hand, brings science into the familiar things of life and encourages regular, careful and sustained observation.

In the past, meteorology in schools has often been coupled with geography with consequent emphasis on climatic averages of rainfall and temperature. A study of types of weather and their causes might be more profitable. This was underlined during the war when pilots of aircraft coming for the first time to the tropics were apt to expect that it rained all the wet season and never in the dry season—a view which had to be unlearned for efficient flight planning.

A knowledge of the scientific basis of elementary meteorology can benefit nearly everyone ; it adds to the appreciation and enjoyment of a day in the open air—even if there is a downpour—and for those whose business or pleasure depend on the elements it ensures that the best use is made of the forecast service to avoid a hurried change of plans.

CAN CARBON DIOXIDE INFLUENCE CLIMATE?

By G. S. Callendar

An interpretation of climatic change in terms of the variable carbon dioxide content of the atmosphere was first proposed some sixty years ago by the famous Swedish physicist, Sevante Arrhenius, who made some of the classic experiments on the absorption of heat radiation by gases. Since then the theory has had a chequered history; it was abandoned for many years when the preponderating influence of water vapour radiation in the lower atmosphere was first discovered, but was revived again a few years ago when more accurate measurements of the water vapour spectrum became available.

Reduced to its simplest terms this theory depends on the fact that, whereas carbon dioxide is almost completely transparent to solar radiation, it is partially opaque to the heat which is radiated back to space from the earth. In this way it acts as a heat trap, allowing the temperature near the earth's surface to rise above the level it would attain if there were no carbon dioxide in the air. Two other gases in the atmosphere, water vapour and ozone, also possess this property of returning back towards the surface some of the low-temperature radiation which would otherwise escape directly to space. The former is present in such large quantities over most of the earth's surface that it plays by far the most important part in the radiation of the lower atmosphere.

It is mainly owing to the predominance of water vapour and the extreme irregularity of its absorption that attempts to assess the effect of carbon dioxide on temperatures have so far met with little success. Even in the laboratory the absorption of radiation by water vapour has proved an exceedingly difficult measurement, and after eighty years of experiments agreement is by no means complete. Carbon dioxide, however, has a simpler and more restricted spectrum and fair agreement has been attained for this gas (*Quart. J.R.Met. Soc.*, Vol. 67, 1941, p. 263).

In the present state of knowledge it seems probable that the change in temperature as a result of variations in carbon dioxide can best be evaluated by comparing the earth to a body receiving a constant supply of heat which is dissipated by radiation through a surrounding medium. Then it can be shown that

$$\frac{dT}{dE} = \frac{T}{4-4E}$$

where T is the temperature of the surface, and E is the emissivity of the surrounding medium towards the surface.

Changes in the amount of carbon dioxide affect the emissivity of the atmosphere at all levels, including the downward component at the surface, and these effects can be calculated with some accuracy from the known absorption coefficients. For example it is found that, with a temperature of 280° A and a downward emissivity of 0·70, a change to double the present

amount of carbon dioxide in the atmosphere should increase E by 1·3 per cent, equal to a temperature rise of 2·1° C (3·8° F) so long as it caused no interference with the heat supply to the surface. Such calculations would occupy too much space to elaborate here.

WHERE THE EFFECT OF CARBON DIOXIDE IS GREATEST

In considering the regions where variations in the amount of carbon dioxide will have most effect on the balance of heat-exchange, one naturally turns to those where the temperature is very low and the importance of water-vapour radiation is reduced ; but there are many low-lying regions of intense cold in the northern winter where the surface heat-loss is small and unimportant because there is little heat-supply from the stagnant air. The active regions of heat-loss in very cold air generally occur at higher levels in the atmosphere, or on elevated land masses such as Central Asia and the Antarctic Continent.

As an example of the former, the heavy convectional rainfall of the tropics depends very much upon the speed at which the middle and upper troposphere can rid itself of the heat energy which is constantly being sent up from below, mainly as the latent heat of water condensation. This heat is radiated away through the thin cold air of the stratosphere, in these regions almost devoid of the protecting layers of water-vapour. It contains, however, the usual proportions of carbon dioxide, in optical densities such that small changes have a relatively large effect on its absorption of radiation from below. Thus an increase of carbon dioxide could reduce the rate of heat-loss from the upper troposphere, which in turn could reduce the vigour of the convection currents and the rainfall, or, alternatively, allow surface temperatures to rise until a new balance was reached. An increase in the aridity of marginal tropical regions and a recession of the glaciers on high tropical mountains might be one of the first indications of this.

Another area of active heat-loss where changes of carbon dioxide could be very important is the upper surface of clouds. This area is vast and its loss of heat often occurs through very dry layers of the atmosphere ; thus, increase of carbon dioxide would mean slower cooling of clouds, perhaps accompanied by less persistent cloud cover and more effective solar heating at low levels.

In the great polar ice caps, where temperatures are very low, and yet for dynamical reasons the rate of heat loss is quite high, the effect of changes of carbon dioxide is doubtless more complex, although we might expect some temperature adjustment to balance the change of emissivity. Whether this temperature adjustment had any effect on convectional processes would depend on its difference from changes elsewhere in the atmosphere. There are many other effects which might be attributed to changes in the amount of carbon dioxide, but enough has been said to indicate where they are most likely to have some influence on world temperatures. The next step is to examine the possibility of such changes being brought about by human agency.

Although those who have studied radiation in the atmosphere will agree that variations of carbon dioxide could have significant effects in the regions just mentioned, they may be doubtful of the possibility of such variations being caused by human activities. For instance, we know that the green parts of plants use this gas to build up their structure, that sea-water can absorb it, that limestone is partially composed of it, and so on. These are all factors in the natural carbon cycle which has been so ably treated by Lundegath (*Der Kreislauf der Kohlensaure in der Natur*, Jena, 1924), Quinn and Jones (*Carbon Dioxide*, Reinhold, 1945) and several others ; but it is not possible to examine these factors here, beyond stating that they are part of a balance maintaining a fairly constant amount of this gas in the air.

It is only during the present century that man has exerted his influence on a sufficient scale to disturb nature's slow-moving carbon-balance, but now his demand for heat and power has led to the transfer of large quantities of "fossil" carbon from the rocks to the air. As one ton of coal or oil produces about three tons of carbon dioxide it is a simple matter to estimate the quantity of the latter derived from the known output of these fuels. This is now about 5,000 million tons per year. One part per million by volume (p.p.m.) in the whole atmosphere is equal to 8,000 million tons of carbon dioxide, the change in the latter over the years may be obtained and compared with the most reliable measurements as in Table 1.

Table 1.—Estimated effect of fuel combustion on atmospheric CO_2

Date	CO_2 from fuel as p.p.m.	Total air CO_2 p.p.m.	Observed value Date	Authority	p.p.m.
to 1900	Small	290	1870–1900	Numerous (*a*)	290
1901–10	3	293	1910	Benedict (*a*)	303
1911–20	5	298	1922	Lundegath (*b*)	305
1921–30	5·5	303	1931	Carpenter (*c*)	310
1931–40	6	310	1935	Buch (*a*)	320
1941–50	6·5	316	—	—	—

Refs. : (*a*) See Callendar, 1940 *Quart. J.R. Met. Soc.*, Vol. 66, p. 395.
(*b*) *loc. cit.*
(*c*) 1937 *J. Amer. Chem. Soc.*, Vol. 59, p. 323.

The observed values in Table 1 appear to indicate a more rapid increase of carbon dioxide than that from fuel alone, but there are several other ways in which man's activities release this gas to the atmosphere in amounts reckoned in thousands of millions of tons ; chief among these are the clearance of forests and the drainage and cultivation of land, by which immense quantities of organic residues are exposed to bacterial oxidation. There is, however, no need for alarm at the possibility of the air becoming contaminated by too much carbon dioxide, because the waters of the oceans provide a reservoir of almost infinite capacity to absorb excess. As the deep waters of the sea move slowly and only a shallow contact surface is involved in the carbon-

dioxide equilibrium, this reservoir does not immediately control a sudden eruption of the gas such as has occurred this century. It will be hundreds or perhaps thousands of years before the sea absorbs its fair share.

Similarly it is possible for the percentage of carbon dioxide to vary considerably in periods of only a few centuries when some exceptional event absorbs large quantities. An example of this is the recolonization of continental areas by forests and peat at the close of the last glaciation.

THE PRESENT TREND OF CLIMATE

It will be seen from the foregoing that the amount of carbon dioxide in the atmosphere may be increased significantly by human activities ; and that there are reasons to expect some slight amelioration in climate to follow from the increase. Hence we may now consider whether the thermometer already shows signs of rising in synchronization with the increasing thickness of the carbon-dioxide radiation blanket, remembering that only very small changes of temperature are expected to occur in periods of a few decades, and that the pitfalls which await the uncritical who venture into this field are numerous. There remain, however, a fair number of temperature records from different parts of the world, of over half a century's duration, which will stand critical analysis both as regards accuracy and the stability of surrounding conditions.

Examination of the trend of mean temperature given by these long records shows that it has been upward during the last half-century in nearly all cases. A few typical figures (Table 2) indicate the order of the temperature rise over this period, as deviations in successive twenty-year means. Some attempt at random selection has been made by taking half the stations under the letter B which have the necessary length of record, and also a wide distribution over the earth.

Table 2.—The trend of temperature in various regions.

20-year deviations from the mean for 1880–1899, in tenths of a degree Fahrenheit.

20 years ending	Britain	Bergen	Boise	Bombay	Batavia	Buenos Aires
1909	3	0	6	3	3	2
1919	3	1	11	5	5	3
1929	4	3	10	7	7	4
1939	7	10	17	7	11	9
1948	10	--	—	—	-	--

Naturally, one would have to go into the history of these observations, comparing them with neighbouring rural sites and so on, before accepting the figures at their face value ; but, without going into details, it may be said that any other half-dozen stations selected at random from widely-scattered regions would show much the same average change of temperature as those given. In marginal sub-arctic regions changes three or four times as great have occurred in the last few decades, but here advectional influences are of paramount importance.

The variations of glaciers, often located in regions where there are no reliable temperature records of long duration, are perhaps even more significant of climatic change than the instrumental readings with their possibility of human error. That they have lately been receding in most parts of the world is well known; recent evidence of this from the southern Andes and New Zealand is specially valuable, because of the lack of old temperature records in the southern hemisphere which can be said to be free from urban influence.

Naturally one would expect any change of climate due to variations in the atmospheric radiation to be world wide in its effects, although there is much doubt as to their nature in a region such as the Antarctic continent, where temperatures are below freezing point at all seasons. In fact, an increase in the amount of ice here might be the ultimate result of higher world temperatures. But in a short article such as this it is only possible to consider the broad outlines of the probable effect of carbon dioxide on climates, and we must be content to leave many of the problems associated with it for future research.

In conclusion it may be said that the climates of the world are behaving in a manner which suggests that slightly more solar heat is being retained in the atmosphere. This could be due to its increasing opacity to terrestrial heat as a result of the additions of carbon dioxide. But the coincidence by itself is no proof, because we do not know if the solar heat has remained constant over the period; it does, however, provide an intriguing example where the expected happens on the grand scale.

METEOROLOGY IN GRAMMAR SCHOOLS

By S. E. Ashmore, B.Sc., A. Inst. P.

Honorary Meteorologist to the Borough of Wrexham

The Royal Meteorological Society, keenly aware of the instructional needs of the science which it sponsors, has always encouraged the formulation of schemes and the publication of informed opinion on the teaching of meteorology. The last article on the subject in its publications having appeared in 1931, the time is now opportune to review the question again. The weather being one of the most profound influences on mankind, there is a good case for making the study of it an important part of a curriculum, or at any rate, giving it more prominence than it has enjoyed hitherto. With the widening of man's activity in earth and sea and sky, the influence of the weather becomes a correspondingly greater factor and hence a wider understanding of its principles is desirable; in this connection it is worth noting that among the Ministry of Education vacation courses planned for 1949 the science course in Norway includes meteorology. The teaching of the subject in schools is easier nowadays than ever before; there is an increase in the number of teachers in schools with training in meteorology, many being ex-service meteorological personnel; again, synoptic data are now readily available. This article is an expression of the writer's personal opinion on the question of teaching meteorology in Grammar Schools, most of the

previous articles having dealt with the subject in what were formerly Elementary Schools.

As an introduction, a few words on meteorology in Colleges may be permitted. I am strongly of the opinion that the study of it in Colleges should be, as at present, post-graduate. Thorough groundwork in mathematics and physics, represented by a first degree, is essential to research workers in meteorology. This matter should be borne in mind in schools, where occasional pupils may hope eventually to take up the subject in the Scientific Officer class. They can profit by normal school instruction in meteorology in the same way as other types of pupil, but first and foremost must come the realisation that their mathematics and physics at this stage are the most important things.

THE TIME TABLE

Much as I would like to see the inclusion of meteorology as a normal subject of the curriculum of Grammar Schools, it is not generally possible yet. One essential, not available everywhere, is an enthusiastic master trained in the subject : another is a head-master in sympathy. Again, suggestions of introducing another subject into the curriculum are certain to raise the question of the over-crowded time-table. Yet in schools where practical subjects such as woodwork and gardening are taught, meteorology could be introduced as an alternative in those forms likely to profit by it ; I do not suggest that meteorology should be taught as a separate subject to all boys when one considers the fairly large number of boys nowadays in Grammar Schools who are quite unable to profit by the academic subjects taught there. When the new regulations regarding School Certificates come into force it should be an easier matter to find a little time for the introduction of the subject into the time-table even of boys who later will have examinations to sit, and perhaps even to facilitate the already existent provision whereby a school can present candidates in subjects such as meteorology, not normally in the standard list of the examining body.

Such introduction of meteorology would mean a certain amount of overlap with other departments. Far from being a disadvantage, this would be preferable to the present absorption of meteorology by other departments, particularly geography. I hope I shall not offend anyone, in addition to those I have already annoyed, by insisting that meteorology is not a branch of geography. The viewpoints of the two subjects are different : the geographer needs ready-made climatological facts and it is the province of meteorology, which, for school purposes differs little from the physics of the air, to study the processes responsible for these facts. We shall see how a meteorological course can help in this respect. At the 1924 conference on meteorology in education Mr. L. B. Cundall complained of the waste of time in the geography course caused by doing meteorology. A separate course would relieve this ; it would undertake such meteorology as is now done in physics and geography courses, but that would not be its only purpose. What, then, should be included ?

EQUIPMENT

As far as a Grammar School is concerned a school weather station should be regarded as indispensable if meteorology is to be taken at all. The subject

would not be started in a school unless there were a capable teacher for it, and he would, *ipso facto*, be an experienced observer himself. I do not advocate mere dabbling with meteorology in schools in any of its aspects, and particularly I feel that observational work, if done, should be done correctly. During wanderings in search of local data I have often come across the battered rain-gauge placed in the optimum position to catch the splash from a roof about four feet away; and the promising-looking Stevenson screen the sole inhabitant of which turns out to be an ancient Six's thermometer with one side reading 2° higher than the other. My answer to all this is "Why not do the job properly?" It will cost little more and be far more interesting. Again, the punctuality, regularity, and accuracy needed for observations are qualities in which training these days is not undesirable.

Of course, there are a host of difficulties, but none are insuperable. Funds are needed, and unenlightened opposition from School Governors is not improbable. It may arise from other sources, too, even from the caretaker, particularly if he is an influential person. Another trouble is the smashing of instruments by hooligans; they will suffer great personal inconvenience, such as laceration from barbed wire, for the delight of seeing a grass minimum thermometer in fragments, so spares should be kept. The maintenance of unbroken observations during holidays is difficult or impossible in some schools; nevertheless it can be done, and pupils will turn out willingly on an icy Sunday morning to deal with snow deposit in the rain gauge. Once a trained nucleus of senior observers has been formed, they will teach younger pupils who accompany them to the station, the teacher adding the refinements to their training. Not all the pupils of the forms doing meteorology need be observers, but they should all understand the work, and there should be a "band of observers", membership of which entails complete fidelity to the cause. In the lower forms there should be considerable emphasis on the observational side, including clouds and their significance, and on the working of the instruments. There is no harm in starting young; a boy of 12 who can read a Fortin barometer to ·002 of an inch is not such a rare phenomenon as one might think, but, of course, at that age, he must be carefully supervised.

A meteorology room is very desirable, for instruction, including experimental work, and the housing of the barometer and barograph, with room for spare instruments and various accessories. The library should be there (its contents will be mentioned later) and there should be wall-space for the exhibition of graphs, charts, photographs and the *Daily Weather Report*. Visits to Meteorological Offices should be undertaken regularly, from the point of view of the instruction and interest of the pupils, and as a refresher to the teacher.

RESULTS

The latent heat of fusion of ice, which is already known, is determined by generation after generation of pupils. In contrast to this, weather observations are *useful*. To begin, they provide data on the climate of the district, comparable with other places, which can be used, if of the required standard, in official quarters, such as the Air Ministry, and organizations such as those

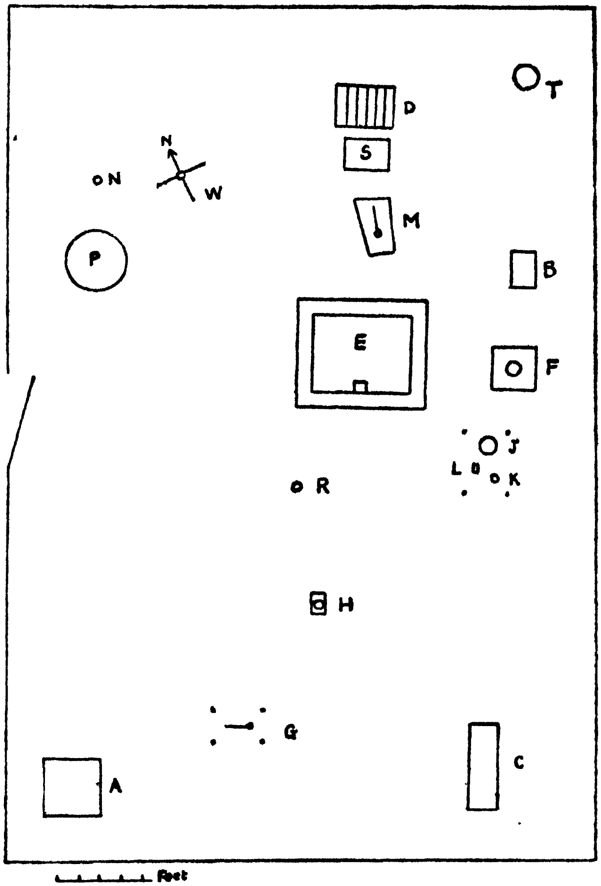


Fig. 1.
Plan of enclosure at Wrexham weather station

A, Bare soil; B, Snow-board; C, Box for rain-measure etc; E, Evaporation tank; F, Experimental evaporimeter; G, Grass minimum thermometer; H, Hyetograph; J, K, L, Earth thermometers at 4ft, 1 ft and 4 in; M, Solar maximum thermometer; N, Nephoscope; P, Deposit gauge; R, Rain-gauge; S, Stevenson screen with duckboards D in front of it; W, Wind-vane; T, Small tank intended to provide large birds with a draught of water more accessible than the evaporimeters.

studying thunderstorms and glaciology. I should welcome an increase in the collection of accurate data from schools, hitherto perhaps more frequent in Wales than elsewhere, but nevertheless nowhere as widespread as it could be. At Wrexham there is a happy arrangement whereby some of the instruments are owned by the municipal authorities and in return the Grammar School supplies all the meteorological data needed by the Borough Engineer. Enquiries for data from all kinds of sources can be satisfied. In school it is obviously preferable for the geography master to be able to display rainfall graphs from the school's own record, rather than to exhibit data of possibly doubtful authenticity culled from a text-book and referring to a place perhaps thirty miles away. Junior mathematics forms doing exercises on graphs or averages can obtain a little local interest by utilising data obtained on the spot. An important feature of the meteorology lesson itself in the lower forms should be the comparison of the school's data with those of other places, through the *Daily* and *Monthly Weather Reports*. Higher up the school more theory can be taught. Elementary synoptic meteorology and the Polar Front Theory can be

introduced in fourth forms and in the fifth form the principles of forecasting introduced. Actual plotting can be done from Air-Met broadcast data. Physical principles such as radiation, condensation and turbulence can be introduced at this stage. There is no textbook available which is suitably graded for schools, but *A Short Course in Elementary Meteorology* by W. H. Pick can be used advantageously. A good list of recommended books was given in *Weather*, December 1948, p. 362, and the reader is referred to this.

SENIOR WORK

It will be long before meteorology can be introduced into schools as a subject at higher certificate stage, and I am, on that account, refraining from outlining any suggestions about it. However sixth form pupils usually have a few periods a week devoted to some study not connected with their specialist subjects. Meteorology is an excellent choice for some of these periods ; even the arts student, whatever career he chooses, cannot escape the weather, and he will welcome a knowledge of its principles. A course for these students can embrace observational technique, if this has not already been acquired, followed, particularly in the case of arts students, by plotting and the practice of forecasting, also upper-air work and the tephigram. Senior science students can go into the theory of this when they know some thermodynamics, and can study other elementary theoretical aspects.

If in a particular school it is impossible to find time for meteorology in the week's time-table, it can be started as an out-of-school activity. The possession of a station will be an outward and visible sign which will enable the meteorologists' club to flourish in a manner not always possible with every school society. Apart from lectures from the staff and senior pupils, talks on applied meteorology should be invited from the Waterworks Engineer, the Municipal Engineer, the Medical Officer of Health, and so on, with an occasional talk in lighter vein such as " Blue Moons and Green Moons ", and a visit now and again to a Meteorological Office.

In the foregoing I have avoided suggesting definite schemes of instruction. At present the problem is one of educational experiment, and other views, which I hope will be expressed, besides my own, are necessary before such formulation is effected.

REFERENCES

Previous articles on the teaching of meteorology have been chiefly concerned with elementary schools. The following is a list of them.

Meteorology for Schools and Colleges by Sir Napier Shaw. Quart. J.R. Met. Soc., Vol. 43, 1917, p. 83.

Meteorology in Education, Geo. Philip and Son, London, 1924.

Prize Competition for Teachers, Quart. J.R. Met. Soc., Vol. 54, 1928, p. 318.

Suggestions for Teaching Weather Study, Quart. J.R. Met. Soc., Vol. 57, 1931, p. 472.

The earth thermometer

The rain gauge

The hyetograph

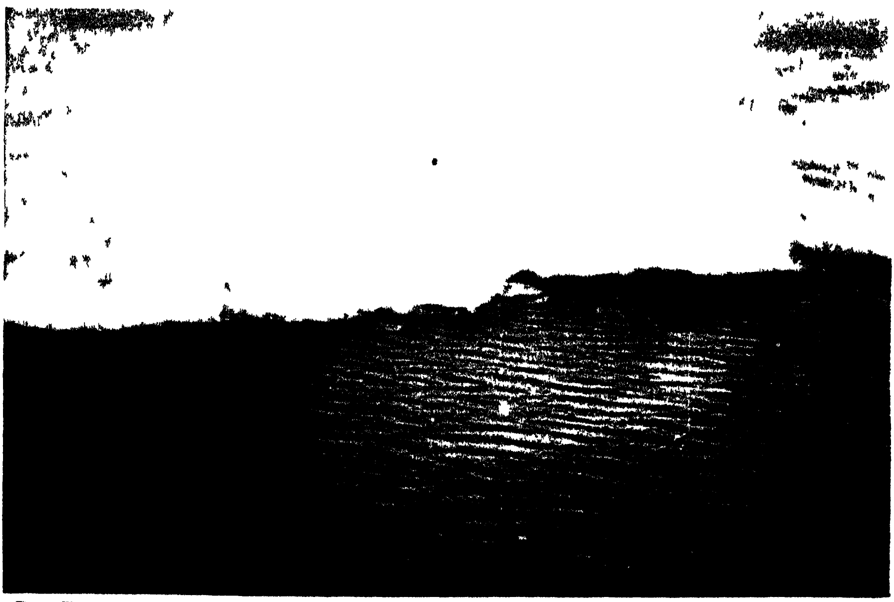
The evaporimeter

Reading the instruments at the Wrexham Weather Station

Photographs by] [*John Davies*

PLATE I

Fog filling a Swiss valley and perfect visibility above



R.A.F. Photograph] [*Crown Copyright Reserved*

Thick fog covering Lincolnshire on 12 January 1940, seen from an aircraft flying at 600 feet over the sea where the visibility is excellent

PLATE II

FOG

By Cdr. C. R. Burgess, O.B.E., R.N.

Have you ever wondered why you can sometimes see a long way, *e.g.* the French coast from the cliffs at Dover, the Isle of Man (and the mountains of Mourne, so I'm told, if you are really lucky) from the top of Snowdon, and far beyond St. Paul's Cathedral from Hampstead Heath, while on other occasions it is difficult to make headway in a car because of fog ? Did you ever wonder why you can see " steam " coming out of the spout, or from under the lid, of a kettle when the water boils ? In this article you should be able to find the answers to these and several other questions relating to visibility or the distance at which objects can be seen.

In pure air that contains little water vapour there is almost no limit to the visibility other than the height of the object and the observer above sea level. As a rule, however, dust particles and water drops are present in the atmosphere in sufficient quantity to limit the visibility to less than 20 miles, and sometimes to less than 100 yards. Visibility over land, especially in and to leeward of industrial areas and big towns, is usually less than over the sea because of smoke and occasionally dust. If the deterioration of visibility is due to smoke or dust alone, it is known as haze ; if it is due in part or whole to water drops it is known as fog, provided you cannot see objects at about 1,100 yards, and as mist if you can see objects up to twice this distance.

During the remainder of this article, however, it is proposed to use the term fog to include mist.

THE PRIMARY CAUSE OF FOG FORMATION

Air has what may seem to be the curious property of being able to contain in the invisible form of vapour, an amount of water that depends upon its temperature ; for instance, air at a temperature of 83° F (near sea level) can hold about 2·5% by weight of water vapour, whereas air at 32° F can contain no more than 0·4%. The amount of water vapour actually contained in the air expressed as a percentage of the maximum amount the air can contain is known as its relative humidity. Let us take as an example some air at 83° F with a relative humidity of 60%. Since its maximum water content is about 2·5% by weight, the actual content of this air must be 1·5%, which is the maximum or saturated content of water at 68° F. Should this air at 83° F be cooled to 68° its relative humidity will become 100%, because it holds the maximum amount of water vapour for air at the latter temperature. We see, then, that if air is cooled, its capacity for holding water vapour decreases and its relative humidity increases, and if the cooling process is carried on for a sufficiently long time, the relative humidity will eventually become 100%, the temperature at this moment being known as the saturation or dew point. Further cooling results in condensation of the surplus water vapour on to minute particles of salt and other chemicals that are mostly products of combustion, while the relative humidity remains about 100%. When these small drops of water are sufficiently plentiful they cause the visibility to fall, and if

this condensation has occurred close to the earth's surface it is known as fog. There is another way in which the relative humidity may be increased, that is by evaporation ; when air flows over water or a damp surface, the temperature of which is higher than that of the dew point of the air, water vapour is transferred to the air. The primary cause of any fog formation is attributable to one of these methods of raising the relative humidity.

SOME FOGS AND HOW THEY ARE CAUSED

To those of us who live inland, and especially if in a low-lying locality, the most common kind of fog is that which initially forms in the evening, or at night, when there is little wind and the sky is clear or nearly so. It is known as *radiation fog*. The earth radiates heat and, provided there is little cloud to intercept this heat and radiate it back again, and provided the sun is low or is below the horizon, its surface temperature falls. Air close to the earth's surface is cooled by conduction (or contact) and, so long as there is only a little wind which is insufficient to mix this chilled air with warmer air well above, the temperature of the surface air may fall to its dew point and condensation will begin, partly on the surface as dew and partly on the particles of salt mentioned above, thus forming fog. This kind of fog forms most easily in valleys and low-lying places because air chilled on higher ground drains down hill like water and collects in valleys and pockets. It is for this reason that wise people, if they are lucky enough to have any choice, don't live at the bottom of valleys. Radiation fog does not form over the sea, or other water surfaces, because their temperature does not fall much at night.

Advection fog is also caused by the air being cooled, though in this instance, as the name implies, the air is cooled by flowing over a surface that is already cold. For example, after a cold spell in winter the ground may be frozen and a damp and mild wind may introduce the change of weather ; the lowest layers of the air are cooled and fog or low cloud are probable. A more frequent example of advection fog, however, is met at sea and is usually known as sea fog. When relatively warm and damp air flows over a cold sea current such as the Labrador Current off Newfoundland and Labrador, fog is the usual result, and when warm and damp air has travelled for about two days on a northerly track in the eastern North Atlantic so that it is reaching progressively higher latitudes and correspondingly colder seas, especially in spring and early summer, fog is again probable.

If you possess a car and are planning a journey, especially if by night, for which there are alternative routes, choose the higher one should the conditions be suitable for the formation of radiation fog, and the lower route if advection fog is likely.

Steaming fog is a good example of raising the relative humidity by evaporation. If the temperature of the air is lower than that of the water (or damp surface), the air close to the surface is bombarded by molecules of water vapour and its relative humidity rises ; the lowest layer of air is also warmed by conduction from the water, and since warm and damp air is lighter

than cold and dry air, the air becomes top heavy, and the warmed air rises in a large number of little columns or upward trickles, in much the same way as water with colouring matter can be seen to rise in a glass container when heat is applied underneath it. But the rising air meets, almost at once, air that is much colder than itself and, if the temperature difference between water and air that has not yet contacted it is sufficiently great, condensation takes place. This steaming fog can often be seen to be rising in a number of wisps ; it does not usually extend more than a few feet high because progressive mixing with drier, although colder, air dries it out, *i.e.* causes the relative humidity to fall below 100%. Steaming fog can be seen over rivers, ponds, marshes, etc., on autumn mornings after a quiet night with a clear sky when the air has been chilled by contact with the cold ground to a very much lower temperature than the water ; in fact, it is not uncommon in such places to see both radiation fog over the land and steaming fog over the water at the same time. *Sea smoke* and *barber* are two names by which steaming fog is known in the Arctic, where it is a common occurrence in winter and a handicap to the navigation of ships. The steam in an unheated bathroom in cold weather when the hot tap is running, and that which comes out of the spout or from under the lid of a boiling kettle or saucepan is the same phenomenon. Remember, though, that it is not real steam that you can see, for steam is water vapour and is invisible.

Frontal fog is another kind caused largely by evaporation and is of especial importance to airmen. As a reader of *Weather*, you must be familiar with the term " front "—which denotes a belt of relatively bad weather between two air masses. The rain near a front is mostly caused by the forced ascent of the warmer air mass over the colder, and as the rain descends it passes through a wedge of the colder air before reaching the ground. Evaporation takes place from the falling water drops and the air is chilled a little because it has to provide the heat necessary for the evaporation process ; the relative humidity therefore increases. Condensation takes place, usually near the cloud base at first, and may extend down to ground level ; the effect is, in fact, a lowering of the cloud base which becomes fog if it reaches ground level.

Smoke fogs are an unpleasant feature of built-up areas, particularly if industrial. Bad smoke fogs are primarily water fogs such as those described above, but rendered worse by smoke particles. Smoke from factory and other chimneys is carried away by the wind—some downwards, some sideways, but a lot upwards, provided the air is not colder near the surface than at a height of, say, 300 feet or so. In the latter event, invariably in the instance of radiation and advection fogs because they are caused by surface cooling, the smoke is unable to rise because of the relatively warmer air above, and the particles of which it consists mix with the water fog. On any night when the sky is clear and there is little wind, smoke from chimneys or bonfires can be seen to blow away horizontally like a ribbon. An increase of temperature with height for 1,000 feet or so above the surface, or at any rate, a decrease of temperature with height of less than the normal, is a characteristic of air

coming from warmer regions, and it accounts for visibility being worse during the day near and to leeward of smoke sources in this air mass than in polar air.

DISSIPATION OF FOG

Essentially fog will only clear when the causes contributing to its formation are removed. For example, radiation fog was caused by surface cooling due to radiation from the earth's surface under quiet conditions; it will clear when the surface becomes warmed or when warmer and drier air from above is brought down by an increase in the strength of the wind. In the former instance the warming can penetrate the fog when the sun has got well above the horizon, say 10° or more, depending upon the depth of the fog. When the amount of heat received from the sun has been sufficient to raise the temperature of the earth's surface, the temperature of the air in contact with the surface is also raised (by conduction), its capacity for holding water vapour is thereby increased and some of the water drops of which the fog consists are evaporated. This process continues at an increasing rate until the fog has "lifted", *i.e.* there is no more condensed vapour on the surface, though there is still some overhead which is known as stratus cloud. Convection currents complete the dissipation by ensuring the mixing of the air in stratus cloud with drier air from below and from above. The fog clears or "burns off", in fact, from the bottom upwards. In late autumn and winter the sun in latitudes greater than 50° does not rise to as high an altitude as 20°, so it may not succeed in dispersing the fog and it will remain throughout the day; moreover, since the warmest part of the day in winter is usually an hour or two after noon, this is the time of day at which the fog is likely to be thinnest if it does not clear altogether.

Wind, owing to friction with the earth's surface, causes the air near the ground to move up and down as well as along, and the stronger the wind the greater the height to which the "turbulent" movement extends. If, then, the wind increases, the fog will also lift or clear entirely, because drier and warmer air from above is brought down to mix with the cold and damp air inside the fog.

Advection fog at sea lifts if the wind blows it over a warmer surface, *i.e.* a patch or current of warmer water. It will also lift, or become thinner, if the speed of the wind increases as explained above. But the most likely way in which it will be completely dissipated is by a change in the source of the air that has hitherto come from lower and warmer latitudes; as long as the temperature of the air is lower than that of the sea surface there can be no fog (except in the extreme case of steaming fog), because the warmer water causes convection and keeps the air moving vertically besides warming it so that its capacity for holding water vapour is increased. Over land, advection fog may lift during the warmer part of the day like radiation fog, owing to the heating effect of the sun on the ground, but the visibility is not likely to improve considerably until there is a change of air mass, *e.g.* until the arrival of a cold (or occluded) front.

Equatorial regions are not worried by fog, apart from occasional radiation fog which may form in low-lying and damp places at night, but is seldom known to survive for more than two hours or so after sunrise, because the sun's rays quickly become strong enough to penetrate the fog and " burn it off " from the bottom. At sea there is no fog, because—

(*a*) the water is very warm, so that there is no chance of advection fog ;

(*b*) there are no fronts as we know them in middle latitudes.

It is dangerous to generalize because there are usually some exceptions due to abnormal circumstances, but it is fairly safe to say that in sub-tropical latitudes, between the parallels of latitude of about 20° and 35°, the air over the land (other than near the eastern coasts of the continents) is usually too dry for fog to form, since much of this area is desert land. Over the sea there are a few isolated localities off the western shores of the continents where there is a comparatively cold sea-water current and fog is often formed when the air comes from a direction other than off shore. There is also the coastal region off China, where fog is frequent during spring when the water inshore is comparatively cold. In higher latitudes fog is not, as a rule, an uncommon event either at sea or on land. It is often not appreciated, however, that there are only a few places, mostly in the vicinity of cold currents, where fog at sea is reported on as many as 10 per cent of occasions ; probably the best-known instance is off Newfoundland and Labrador. The frequency is higher in late autumn and winter on land and in coastal regions near big cities and industrial regions such as the mouth of the Thames and the Straits of Dover, or in the approaches to New York, because of smoke. It is most frequent of all in the Arctic ; along much of the Northern Sea Route between North-West Russia and the Pacific where there is much ice and the sea is very cold, fog occurs on between 10 and 15 days a month during much of the limited navigation season.

Books Received

Oscillations of the earth's atmosphere by M. V. Wilkes, 74 pages, C.U.P. 1949, 12s. 0d.

Some recent researches in solar physics by F. Hoyle, 134 pages, 8 figures, 36 tables, C.U.P. 1949, 12s. 6d.

Atmospheric turbulence by O. G. Sutton, 107 + viii pages, 4 diagrams, Methuen 1949, 6s. 0d.

Of these new books, the first two are Cambridge Monographs on Physics and the third is a Methuen Monograph on Physical Subjects. The aim in each case has been to supply a clear, up-to-date account of the subject with especial emphasis on recent research, making full use of mathematics.

Professor Sutton's well-knit writing is already known to readers of *Weather*, and they will find the books by Wilkes and Hoyle have been well introduced by Professor Dobson's article, last month, on " Some solar and terrestrial relationships ".

Full reviews will appear in the *Quarterly Journal of the Royal Meteorological Society* and *The Observatory*.

THE ORIGIN OF THE FAHRENHEIT TEMPERATURE SCALE

By E. L. Hawke, M.A.

How did the Fahrenheit thermometric scale originate? Some of us were required to cope with this question when we sat for elementary science exams at school, and no doubt we congratulated ourselves on scoring full marks for what we, in common with the examiners, regarded as the right answer. It is thus somewhat disconcerting to find that modern pundits are out of agreement on the matter. Did we not earn our places in the class lists so well as we fancied? In the 150th Anniversary Commemoration Number of the *Philosophical Magazine*, recently issued, two eminent authorities on the history of science and scientific instruments, Professor H. Dingle and Mr. R. S. Whipple, give conflicting accounts of the origin of Fahrenheit's scale as we know it today. Mr. Whipple supports the traditional belief that Fahrenheit adopted as "zero" the lowest temperature obtainable by mixing ice and salt. Professor Dingle would have it otherwise. He maintains that Fahrenheit copied his scale from one Römer (not to be confused with Réaumur), who made the temperatures of melting ice and human blood 7·5° and 22·5° respectively. Fahrenheit, says Professor Dingle, sub-divided each Römer degree into four, obtaining values of 30° and 90° for the two fixed temperatures. Finally, to avoid "awkward fractions", these were increased by one-fifteenth and the present scale was produced.

From a history of the Fahrenheit scheme of graduation set out by Henry C. Bolton in his book *Evolution of the Thermometer*, 1592-1743 (Chemical Publishing Co., Easton, Pa., 1900) it would seem that so far as the scale with which we are now familiar is concerned Mr. Whipple's version of the matter is the more correct, and that those of us who satisfied the examiners with our answers need not feel uneasy. Bolton quotes (*loc. cit.*, *pp.*69-70) the following passage from Fahrenheit's own writings: it is apparently taken from one of five short papers contributed by him between 1724 and 1726 to the *Philosophical Transactions* of the Royal Society (in which he held Fellowship from May, 1724 until his death on 16 September 1736):— "The division of the scale depends upon three fixed points which are obtained in the following manner: the first point below, at the beginning of the scale, was found by a mixture of ice, water and sal-ammoniac, or also sea-salt; when a thermometer is put in such a mixture the liquid falls until it reaches a point designated as zero. This experiment succeeds better in winter than in summer. The second point is obtained when water and ice are mixed without the salts named; when a thermometer is put in this mixture the liquid stands at 32°, and this I call the commencement of freezing, for still water becomes coated with a film of ice in winter when the liquid in the thermometer reaches that point. The third point is at 96°; the alcohol expands to this height when the thermometer is placed in the mouth, or the arm-pit, of a healthy man and held there until it acquires the temperature of the body. If, however, the temperature of a person suffering

from fever, or some other disease, is to be taken another thermometer must be used having a scale lengthened to 128° or 132°. Whether these degrees are high enough for the hottest fevers I have not examined; I do not think, however, that the degrees named will ever be exceeded in any fever." (Incidentally it may be remarked that according to modern medical theories your physician will take a very poor view of your prospects if your body temperature rises to 109° F).

Bolton goes on to state that Fahrenheit made his thermometers with different scales at different times and gives this table of equivalents:

No. 1 Large	No. 2 Medium	No. 3 Small	Centigrade
Degs	Degs	Degs	Degs
90	24	96	35·5
0	12	48	8·8
–90	0	0	–17·8

No. 1 was an old Florentine scale, the use of which seems to have been abandoned by Fahrenheit at some date between 1709 and 1714. Bolton discusses the derivation of the two subsequent scales at considerable length. Although he allows that uncertainty exists as to the precise basis of the fixed points he makes no mention of Römer's name in this connexion.

The proportions of ice, water and sal-ammoniac (or sea-salt) in the mixture employed by Fahrenheit for determining his zero are said to be unknown: Rüdorff, Bolton tells us, showed that the temperature obtained by mixing 100 parts of snow and 33 of salt is –21·3°C and that the corresponding value yielded by 100 parts of snow and 25 of sal-ammoniac is –15·4°C, both differing materially from the –17·8°C represented by the modern Fahrenheit zero. It is thus inaccurate to say that this zero is the lowest point obtainable by a mixture of salt and ice. In that respect the origin traditionally ascribed to the scale is wrong.

According to Bolton, Fahrenheit did not set out with the intention of dividing the interval between the zero and the boiling point of water on his No. 3 scale into 212 parts. When constructing thermometers for measuring temperatures above the 0-96° range he merely extended the scale by adding more degree spaces of equal size. It so happened that the division marked 212 coincided with the level of the thermometric fluid at the boiling point of water, under unspecified conditions.

In view of the uncertainty attaching to both the zero and the boiling-point marks, and of the fact that the freezing point of water varies with its state of purity and quietude, there is no wonder that the Fahrenheit scale as we have it today differs somewhat from the original schedule. The accepted value for the average sub-surface temperature of the normal human body in good health is now not 96° but 98·4°F. By the way, how, when, and by whom was this average determined? Perhaps some medical reader of *Weather* can enlighten us.

METEOROLOGY AS A CAREER

By P. J. Meade, O.B.E., B.Sc.

Anyone in this country wishing to follow meteorology as a career must, in general, seek a post in the Meteorological Office which is the State service responsible for meeting the requirements of the general public, the Royal Air Force, the Army and Civil Aviation, as well as other government departments. An exception is, however, the Royal Navy, which has its own meteorological service to deal with the special problems of naval operations.

The work of a large meteorological organization is so varied that a simple definition of meteorology, such as "the scientific study of the atmosphere" hardly gives an adequate idea of the many branches of the subject or of the large number of problems which have to be dealt with. The importance of the weather in relation to flying is well known, but there are also other activities—agriculture, various forms of transport and industry generally—in which meteorology is a factor of the greatest economic concern. In addition there are the special aspects of meteorology, for example, the earth's magnetism, atmospheric electricity and seismology, which are studied at the observatories of the Meteorological Office.

In the first place meteorological work consists of making regular or continuous observations of the different atmospheric elements, temperature, pressure, humidity and so on. The task is then to analyse and correlate the records in an endeavour to establish an ordered sequence in the changes which take place, whether they occur over a long or short period of time. The first stage in the analysis is generally graphical or statistical. As examples of the former one may cite the weather maps on which are plotted the weather observations made at a certain time at a large number of stations distributed over a region of the earth. These maps, which may be drawn for conditions at the surface and at fixed pressure levels above the surface, give a three-dimensional picture of the weather, and form the basis of forecasting. Statistical methods of examining records are illustrated in climatological summaries.

Since weather observations are the starting point of meteorological work, any advances that are to be made in the science depend on increasing the volume of data available and improving their accuracy. Additional data can be obtained by measuring more frequently those elements which cannot be recorded continuously and by extending the network of observing stations as was done when the Ocean Weather Ship scheme was introduced. The accuracy of observations depends on the instruments employed and efforts are constantly being directed to reducing the errors of existing instruments and designing new ones of greater accuracy.

Owing to the nature of its work, the Meteorological Office is a department of the Scientific Civil Service and consists almost entirely of scientific staff. These are divided into three classes—*scientific assistants*, *experimental officers* and *scientific officers*—each class having a number of grades. The chief educational requirements for entry to the Meteorological Office are a good knowledge of mathematics or physics, preferably both. Normally *scientific assistants* must have reached matriculation or credit standard in these subjects, *experimental officers* Intermediate B.Sc. or Higher School Certificate standard, and *scientific officers* require a good honours degree in either mathematics or physics.

New members of the Meteorological Office are given a course of instruction at a training school, where they learn to apply their scientific knowledge to the problems presented by the weather. The major part of the work of the Office

is concerned with forecasting and in consequence this aspect of meteorology receives most attention during the training courses. The scientific assistant learns, in addition to some theory, how to make observations, both visual and instrumental, the various codes which are so essential for the rapid interchange of weather reports between countries, and the plotting of weather maps or, as they are more commonly called, synoptic charts. Officers, who are responsible for all the forecasting, become proficient in these duties as well but they also go more deeply into meteorological theory because weather prediction requires a detailed understanding of the various physical processes that can take place in the atmosphere.

When his training course has been completed, the new member of staff may be given a posting to a meteorological office on a Royal Air Force station or at a civil airport, or he may go to the Central Forecasting Office at Dunstable or to an Observatory or other research establishment. In his work at a station the meteorologist soon appreciates the importance of the weather in our daily lives and this does much to sustain his interest in the subject. While all work eventually becomes routine to a certain extent, the meteorologist can always detect something new or significant in the atmosphere which is his special study. Changes in the barometer or thermometer do not occur without cause and they can usually be related to changes in other meteorological elements, such as the shape and height of the clouds, the visibility, the direction and speed of the wind. Another important factor adding to the interest of the work is that weather observations, besides being scientific measurements valuable to the research worker, have an immediate practical value. For example, the assistant on duty at an airfield is aware that the results of his observations are distributed without delay to all other meteorological offices and also to aircraft in flight near his station, and the knowledge that an error in a pressure reading or in an estimate of cloud height transmitted to an aircraft may make all the difference between a safe flight and an accident, is an incentive to careful and accurate observation.

The total number of stations manned by Meteorological Office staff in the United Kingdom exceeds 150. There is thus a wide choice of locality to which staff may be posted, but every effort is made to meet personal wishes, especially in the case of younger assistants who, if at all possible, are posted to stations near their homes.

The Meteorological Office is also responsible for a number of stations overseas. These are mainly to be found in Germany, the Mediterranean and Middle East areas, the Far East and in the West Indies. During their career, therefore, staff may expect to serve one or two tours abroad. It is also open to staff to volunteer for a one-year period of duty on an Ocean Weather Ship. Not all this time is spent at sea, however. Each voyage usually lasts 28 days and is followed by about 10 days' leave before the next trip begins.

A point concerning national service is worthy of mention, because it affects a number of scientific assistants who are recruited from the age of 16½ upwards. These assistants are not exempted from national service when they reach military age, but they may join the meteorological branch of the Royal Air Force and so continue in the same type of work as before their call-up. Most of the assistants concerned take advantage of this opportunity and return to the Meteorological Office as civilians as soon as their military service is ended. By so doing they are allowed to regard their service in the Meteorological Office as unbroken.

Promotion in the Meteorological Office may be achieved in two ways. The most usual form of promotion is from one grade to another within a class

such as from scientific assistant to senior scientific assistant. Promotion may also be gained by transfer from one class to the one above, for example, from the assistant to the experimental officer class or from the latter to the scientific officer class. The precise conditions for class-to-class promotion have not yet been decided, but it will be obvious to the individual who wishes to enter the class above that his chances would be considerably improved if he were to acquire the academic qualifications which are considered normal for that class. The Meteorological Office operates a scheme for assisting those members of the staff who are taking higher studies in subjects related to their work. For approved courses of study, all expenses are paid and time off (with pay) is granted for private study or to permit attendance at lectures.

In this article it has been possible to deal with only a certain number of the relevant questions concerning meteorological work. If, however, enough has been said to arouse interest in meteorology as a career further information may be obtained by writing to the Air Ministry (S.2b.), Cornwall House, Waterloo Bridge Road, London, S.E.1.

WEATHER OVERSEAS

We have pleasure in announcing the following additions to the lists of Overseas Representatives published in our issues of May and July 1949.

BOLIVIA: Ismael Escobar V., Ministerio de Agricultura Ganaderia y Colonizacion, La Paz.

MAURITIUS: E. G. Davy, Aerological Station, Vacoas.

NEW ZEALAND: J. W. Hutchings, Meteorological Office, P.O. Box 722, Wellington.

THAILAND: K. V. Dhararak, Meteorological Department, Royal Thai Navy, Bangkok.

BURMA: Dr. Po E, Burma Meteorological Department, Rangoon.

HOLLAND: A. Hauer, Koningijk Nederlands Meteorologisch Instituut, De Bilt.

SWITZERLAND: J. Haefelin, Hochstrasse 39, Zurich.

SOUTH AFRICAN NEWS LETTERS

In April last the South African Weather Bureau issued the first of a series of monthly news letters. The purpose of these official circulars is to record activities in the Weather Bureau and, at the same time, to provide a medium for keeping members of the staff, particularly those at outstations, informed of matters of general interest. In this inaugural number, officers in charge of Weather Bureau outstations are asked to communicate items, which they consider may be of interest to others, for inclusion in future issues. Three of these monthly letters have now been received at our Editorial office and a selection of news items from them which we think will be of some interest to our readers are published below. A feature of these letters is the paragraphs devoted to such staff matters as appointments, transfers, promotions, etc., and more personal items, *e.g.* awards to and marriages of members of the staff. We warmly welcome this scheme which we hope will act as a pointer towards the provision of similar facilities in other state meteorological services. In these days of wide meteorological commitments there are many who have to spend their lives in remote places and any effort to promote personal contacts with colleagues is to be commended.

OBSERVATIONS FROM THE SOUTHERN OCEANS

On 4 May 1949, daily radiosonde ascents were commenced from lonely Marion Island, lying in the "Roaring Forties", some one thousand miles to

the south-east of the Cape of Good Hope. The South African Weather Bureau maintains a reporting station on the island and equipment for an automatic weather station is to be tested there.

INSPECTION OF METEOROLOGICAL STATIONS

Two international panel vans, modified to carry meteorological instruments and each fitted with a bunk, were delivered recently to Pretoria for the use of station inspectors. On April 25 and May 9 " mobile " inspectors left on visits of inspection to stations in the Transvaal and Bechuanaland, inaugurating a programme intended to cover all reporting stations of the Weather Bureau.

EFFECTS OF A TORNADO

An interesting illustration of the rapid fall of pressure associated with a tornado is provided by the effects of the tornado which passed over a school at Bronkhorstspruit, 30 miles east of Pretoria, on 10 May 1949. In the school laboratory the stoppers and contents were blown out of numerous bottles which remained on the shelves otherwise undamaged; the cap and sulphuric acid were also removed from an accumulator. Much damage was caused along the six-mile path of the storm by the violent winds, *e.g.* a concrete block weighing 70 lb and attached by a wire to a wind charger was lifted through the roof of a building.

ROYAL GEOGRAPHICAL SOCIETY AWARD

Congratulations to Mr. A. B. Crawford, B.E.M., Port Meteorological Officer at Cape Town, on the award of the Cuthbert Peak grant by the Royal Geographical Society for surveys and meteorological work carried out at Tristan da Cunha and Marion Island. The presentation was made by General Smuts, in London, on 13 June and accepted by Mr. Egeland, the Union High Commissioner in London, on Mr. Crawford's behalf.

NIMBUS: A NEW BOLIVIAN MAGAZINE

Meteorological activity in South America has grown rapidly in the last few years, but the number of meteorological journals published there is small. We welcome the appearance of *Nimbus*, the new quarterly journal of the Bolivian Meteorological Society, edited by Professor Ismael Escobar V. The first number, that for the first quarter of 1949, contains such varied articles as " The variations of annual rainfall in Bolivia " by J. J. Rico Negretty, " The effect of wind on buildings " by H. Mansilla and " The locust problem in Bolivia from the meteorological point of view " by R. P. Alcala. The editor states that it is particularly hoped to publish articles dealing with the applications of meteorology to the economic life of South America and to provide in bibliographies and reviews a guide to meteorological information on South America. We hope that this new venture will meet with every success.

LETTERS TO THE EDITORS

Humidity at the tropopause

Enough ascents into the stratosphere have now been made by the Meteorological Research Flight at South Farnborough to amplify and correct impressions given by the first few ascents (Dobson, G.M.B. 1946, *Proc. Roy. Soc.*, London, A., Vol. 185, and others elsewhere).

Much importance has been attached to the sudden fall of frost point at the tropopause and the consequent 'extreme dryness' of the air in the stratosphere—leading to such phrases as 'another world', 'remarkably little diffusion of air across the tropopause' and so on.

The Meteorological Research Flight ascents do confirm that a steepening of the lapse rate of frost point is a fairly common feature of the tropopause, especially when the temperature lapse rate discontinuity is very sharp. (A detailed study of the behaviour of the frost point and the temperature at and near the tropopause has been made by H. C. Shellard (to be published shortly in the *Meteorological Magazine*). But this steepening of the frost point lapse rate is a purely local effect from which, at slightly higher levels, a quick recovery is made.

In Fig. 1 we show a mean ascent curve obtained from all ascents in which complete data are available from 10,000 to 39,000 ft, and in which the tropopause height was between 35,000 and 37,000 ft (14 ascents). The tropopause is clearly reflected in the temperature curve, but there is very little sign of it on the frost point curve. There may be a change

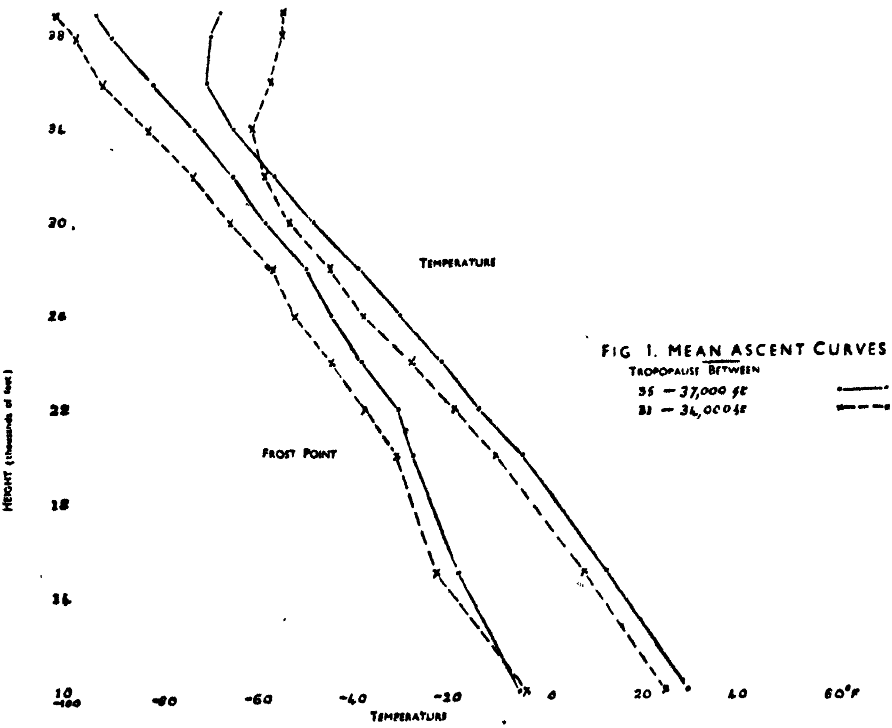


FIG 1. MEAN ASCENT CURVES

of regime at about 28,000 ft, to which we shall refer again, but a good estimate of the frost point at 39,000 ft (in the stratosphere) could be obtained by extrapolating from the readings at 28,000, 30,000, 32,000 and 34,000 ft—all in the troposphere.

In the same figure we show similar data from all ascents which had the tropopause between 31,000 and 34,000 ft. It is remarkable how similar the frost point curves in these two cases are; and we wish to draw attention, particularly, to the fact that in both there are the same indications of a change of regime at about 28,000 ft—where the temperature is about −40° F.

This is also about the level of separation of the 'upper' and 'lower' circulations discussed by A. H. R. Goldie some five years ago in an unpublished research paper (M.R.P. 213). At all events, as regards frost point, or absolute humidity, it seems that the tropopause is an incidental feature, generally in the 'upper' air mass, whose position is governed, perhaps, by laws of radiative equilibrium.

I am indebted to the Director of the Meteorological Office for permission to publish this letter.

Farnborough, Hants RONALD FRITH

Wet Januaries and Septembers

In *Weather* for December 1948 p.372 Mr. D. H. Thomson considers it misleading to take the 1881-1915 average monthly rainfall as the dividing line between wet and dry months: While it may be true that a better and more useful definition of wet and dry months might be months with rainfall outside the range $\pm$ 20 per cent. from the average, such a definition is by no means necessary in considering the significance of runs of wet months, neither, for this purpose, is it necessary that the 1881-1915 average for any month should be the same as the long period average.

Formally the problem may be put in this form : given a sequence of n elements of which l are A (say wet years) and m are B (dry years), where $l + m = n$, what is the probability that in a random arrangement of the A's and B's the longest run of A's will be greater than or equal to s elements ? This probability (P) has been shown (G. Bateman, *Biometrika*, 1948, Vol. 35, p. 97) to be

$$P = \frac{1}{{}^{n}C_{l}} \left[\sum_{j=1}^{k} (-1)^{j+1} \; {}^{m+1}C_{j} \; {}^{l-js}C_{m} \right]$$

where ${}^{n}C_{l}$ etc., are the binomial coefficients and k is the largest integer in l/s.

Over the 222 years 1727-1948 there were 104 wet and 118 dry Januaries (treating the 2 years of 100% as one wet and one dry) and the largest run of wet months was 13. Putting $l = 104$, $m = 118$, $s = 13$, in the above formula gives $P = .004$. This implies that in a large number of sets of random arrangements of 104 wet and 118 dry months, on the average only 4 in 1,000 would have a run of wet months equal to or greater than 13. A run of this length is thus an exceptional event in a random arrangement of the given number of wet and dry months. We therefore conclude either that an exceptional event has occurred or that the arrangement is not random, there being a tendency for one wet month to be followed by another.

Over the same 222 years September was wet 136 times and dry 86 times (apportioning the 2 of 100 per cent. as before) and the formula gives $P = .014$ for $s = 17$, the longest run observed.

There is however another point that must be borne in mind in considering the abnormality of these runs of wet years. We have 12 sets of records each of 222 years, one for each month, and the two months January and September have been picked out because they showed the longest runs of any month. Consider the case where the chance of a random arrangement giving a longest run equal to or greater than s is say .005. Then the chance that no run is as long as s is .995 and the chance that in 12 sets none shows a run as long as s is $(.995)^{12}$. Therefore the chance that at least one of the 12 sets contains a run of s or longer is $1-(.995)^{12}$ or about .06, which hardly indicates an exceptional event. In view of this I should hesitate to describe the runs of wet Januaries and Septembers as abnormal in the sense that they are inconsistent with the hypothesis that wet and dry months of given name occur in a random order. The observed runs are of course abnormal in the sense that they have only been observed once in 222 years, but such runs are expected occasionally in a long series of observations.

The above has only dealt with runs of wet months but can equally well be applied to runs of dry months. The formula given is not however applicable if we wish to consider runs of either wet or dry months ; for this the formula is more complicated and reference should be made to the paper quoted.

Harrow, Middlesex R. H. DAW

I feel that the criticism by Mr. D. Halton Thomson of the note by Mr. E. L. Hawke on the above topic calls for some comment. Let us confine our attention to the wet Januaries. If one plots January rainfall, say since 1900, either as depth or as percentages of some mean, a general upward trend will be evident during the past thirteen years or so ; it does not

matter whether the mean is for 1881-1915, or some longer period.

The statistical argument, correct though it be, does not invalidate Mr. Hawke's statements ; if I understood his letter properly, what he wished to bring out was the fact that January has recently become a much wetter month, rather than the finding of a series of Januaries all yielding more than 100 per cent. of the 1881-1915 average, although this was actually the case. Had Mr. Hawke employed a longer-period average, and found one or two Januaries a little below that average, the fact would still remain that, generally, January has recently become wetter. Obviously, to remove the difficulty, another method should be used, and an ideal one already exists in the aggregate diagram so fruitfully used by Capt. W. N. McClean. If Mr. Thomson has access to the requisite data, I suggest that the aggregate diagram be applied to January rainfalls ; the desired result will emerge regardless of what period is used for the average.

I do not wish the above to be construed as a defence of the 1881-1915 average—I have been known to criticise it myself ; but the phrase " the long-period average " in Mr. Thomson's letter, without further qualification, is undesirable. A rainfall period could, in theory, be made so long as to become invalid for present-day comparison because of secular climatic change. Several other factors come into it also ; the whole question has been dealt with by Miss N. Carruthers in the *Quarterly Journal* for Jan-Apr 1945.

Wrexham, North Wales S. E. ASHMORE

Pilot-Balloon Ascent of 22 miles

I have just read a letter in the July issue of *Weather* from Mr. Z. Ozorai, about a pilot-balloon ascent that I followed last year to an estimated height of over 22 miles (*Weather*, Aug. 1948, p. 252). I would point out that the balloon used was a neoprene one of U.S.A.A.F. issue, this synthetic rubber being made to withstand great extremes of temperature and still to retain its elastic properties, also to exclude the errors due to porosity in ordinary latex rubber balloons. I have examined the graphical plot of the ascent, which shows fairly constant conditions up to 85,000 ft. There is no sign of a gradual increase of wind speed, which would be expected had the balloon developed a small leak. Above this height the wind rapidly increased to become very steady at 110°/120 kt.

The evidence appears to be in favour of the mass of gas inside the balloon remaining constant. Assuming this to be so, however, the rate of ascent at great heights would still fall off very slightly, but would probably be small enough to go undetected in an examination of the graphical plot. It is on the magnitude of this latter error that I would be interested to hear, although in this particular case it would be more of physical than of meteorological import.

King's College, Cambridge A. J. WELLS

METEOROLOGICAL OFFICE LECTURE

Professor T. Bergeron, the Swedish authority on cloud physics, delivered a stimulating lecture at the Science Museum on Thursday, 15 September 1949. He described the physical basis of artificial rain production using suitable nuclei for ice crystals and explained why convection cloud, layer and frontal cloud provide few opportunities for useful rain-making. Orographic cloud might prove more suitable, he suggested ; indeed, heavy rain in hilly and coastal areas is often a result of natural stimulation of rain from orographic cloud by ice crystals falling from higher frontal cloud.

Professor Bergeron concluded his lecture with a series of excellent coloured lantern slides of meteorological and scenic interest.

UNIVERSITY COLLEGE METEOROLOGICAL SOCIETY

A meteorological society was formed early this year by students and staff of University College, London. The next meeting of the society will be at 5 p.m. on Tuesday, 1 November 1949, in University College. Students of the University of London are invited. Particulars may be obtained from the Secretary, Meteorological Society, University College London Union, Gower Street, W.C.2.

THE WEATHER OF SEPTEMBER 1949

DRY GENERALLY ; ABNORMALLY WARM

More records were broken during this month, the mean temperatures at Kew and Ross-on-Wye, for example, being the highest on record for September, while the night of 4th to 5th was the warmest on record at Greenwich (69° F) for any month since observations began in 1841. Rainfall was again low except in the South-West and along the south coast of England ; severe restrictions on the use of water are in force locally in the East.

A southerly type prevailed for the first five days, culminating in maximum temperatures of well over 80° F in England on 4th ; for Kew it was the warmest day of the year with 86° F, while 90° was recorded at Mildenhall, Shoeburyness and Coltishall. On 6th a westerly type was established ; temperatures fell a little but remained well above normal. In the North and North-West weather was unsettled, but rainfall amounts were small. An anticyclone developed off the west coasts of Scotland and Ireland on 11th and easterly winds became general. A trough of low pressure extending eastwards along the English Channel on the night of 13th to 14th brought heavy rain to south-coastal regions, while reports of a small depression developing at the eastern end of the trough, forecast to move north-westwards over South-East England, raised hopes of rain on that dry district that gave way to disappointment. For about five days from 11th an almost stationary non-frontal depression, possibly a comparatively mild tropical storm, was responsible for gales about 700 miles west of the Azores. From 20th to 23rd some thundery rain fell over most of the country, heavy falls being reported in the South-West where Weston-super-Mare recorded 75 mm. Thereafter the weather was fair and warm everywhere.

Readers may not have noticed that the report of the committee of inquiry into the disastrous fires near Bordeaux in August includes the finding that the isolation tactics were thwarted and many firefighters lost their lives because of a whirlwind which swept through the critical area ; some trees had actually been uprooted. Drought has brought difficulties of rail transport in Tanganyika, where oil tanks and wagons have to be used for carrying water instead of oil. From Tokyo we learn that roofs were torn off and hundreds of houses flooded by torrential rains that accompanied a typhoon on 31 August.

	TEMPERATURE (°F)				RAIN (mm)*			SUNSHINE (hr)		
	Long period Average Max.	Long period Average Min.	This month Extreme Max.	This month Extreme Min.	Month	Diff. from Av.	Last 12 months	Month	Diff. from Av.	Last 12 months
Kew Obsy.	65·7	51·3	86	48	9	—41	397	158	+12	1760
Gorleston	64·2	52·0	79	50	39	—11	337	173	+15	1751
Birmingham	62·8	49·7	81	48	28	—18	607	145	+21	1542
Falmouth	62·8	52·7	71	54	91	+17	805	157	— 1	1998
Valentia	61·2	52·0	73	46	80	—31	1283	157	+33	1389
Aldergrove	60·8	47·9	71	36	49	—16	694	145	+23	1380
Holyhead	60·5	52·7	74	43	53	—15	649	206	+63	1854
Tynemouth	60·3	50·1	81	49	27	—19	357			
Renfrew	60·4	45·6	74	44	60	— 6	1028	116	— 2	1444
Aberdeen	59·1	44·8	71	40	48	—20	687	125	—10	1569
Stornoway	56·8	47·1	66	40	87	—14	1141	156	+46	1320

* 25 mm = 1 inch (approx.)   † The Lizard   C.R.B.

THE USE OF SMOKE IN THE STUDY OF ATMOSPHERIC MOVEMENTS

By E. G. Richardson, B.A., Ph.D., D.Sc.

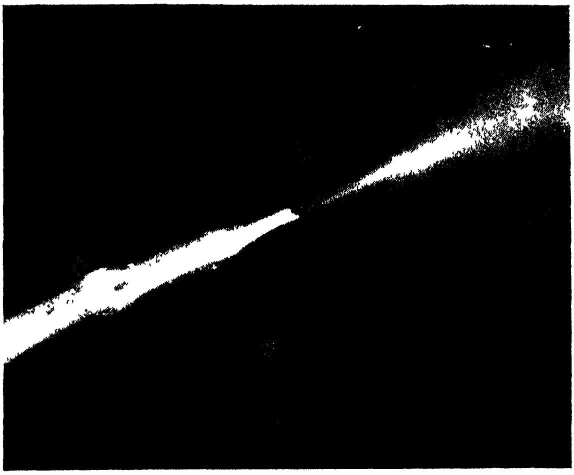
The diffusion of smoke over a large area out-of-doors is a phenomenon of civil and military importance in connexion with the spread of airborne pollution from factory chimneys and in the spread of smoke screens respectively. This problem has formed the subject of many years' study by Professor O. G. Sutton and his colleagues at the Chemical Defence Research Establishment at Porton and is the subject of two recent articles by him in the *Quarterly Journal of the Royal Meteorological Society* (1947, Vol. 73, pp. 257 and 426). Professor Sutton has also discussed the application of his theories to photographs of the Bikini explosion in *Weather* (Vol. 2, p. 105). It is my object in this note to discuss the applications of smoke to the study of local atmospheric motions comprising areas ranging from a few square inches to a hundred square feet.

A puff of smoke when it is formed in the atmosphere is carried along by the wind and so acts as an indicator of the general velocity of the wind. At the same time it diffuses into the atmosphere, the rate of diffusion being determined by the gustiness of the air. Thus one may obtain information about air movements by letting smoke into it at a definite point and observing the general drift of the smoke away from this point, or by estimating the width of the spread of the plume at a specified distance downwind of the source.

An example of the former application is the production of smoke puffs at an inaccessible portion of the atmosphere by exploding smoke shells fired from a gun and estimating the wind velocity at that height by visually tracing the path of the smoke—for the short time that it remains compact—from two theodolites on the ground or the ship ; not an easy task for the spotters !

A common instance of the use of smoke in experimental aerodynamics is in the study of the flow over a body which has to move rapidly through the air, in which we may find either of these two features of smoke trails—drift and diffusion—given special attention. Since protruberances on the surface divert the flow, if large enough, and in any case, break up an erstwhile steady streaming, we often find smoke used to see how effective is an alleged improvement in the smoothness of the surface. The pre-war experiments in streamlining certain British locomotives did not so much improve their performance on the road as clarify the outlook of the enginemen from the cab windows. Here was an unusual aerodynamic application, for the smoke was an essential feature and not an *ad hoc* part of the experiment.

When the obstacle in the stream is an aircraft wing or the hull plates of a ship, a model is generally made and the " indicator " let into the fluid from a fine nozzle upstream in the way of the model. A major aspect of interest is to find at what points the flow over the solid boundary becomes turbulent and breaks away from the surface. This may readily be done by letting smoke into the air, or a concentrated solution of a dye into the water, near the leading

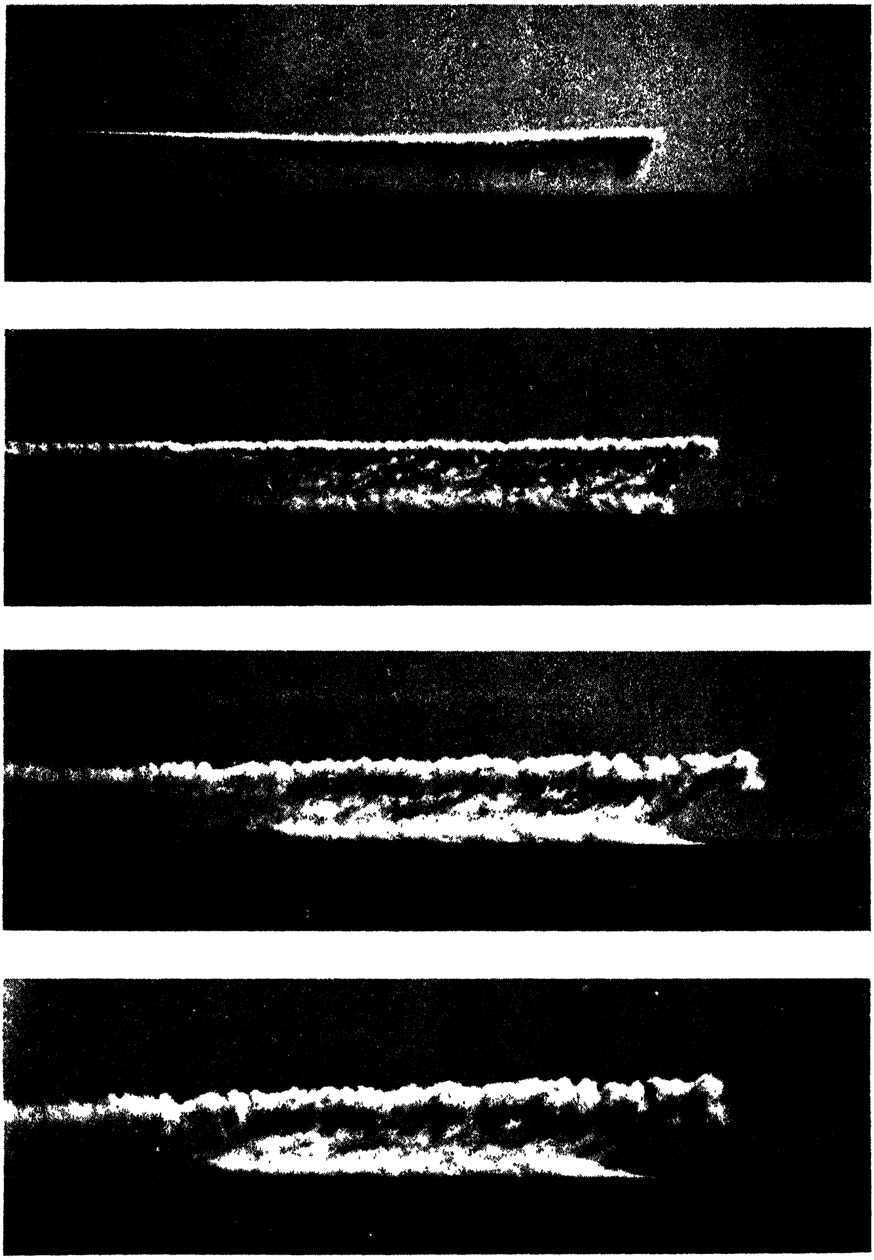


From above

From the side

Simultaneous photographs of a jet of smoke from a nozzle

PLATE III



Successive pictures of smoke curtain laid inshore from off the sea at Hayling Island

PLATE IV

edge of the model and seeing where it breaks away from the surface. Another method—in air—is to paint the model with a volatile gloss which evaporates readily in the laminar region where it is subject to a high rate of shear, but tends to cling to the surface behind the point where the transition to turbulent flow has taken place. At the Royal Aircraft Establishment it has been found possible to make this sort of experiment on a full-scale aircraft in flight, the smoke trail being laid in the first trials from a tall factory chimney and later from a pilot aircraft. Here the function of the smoke particles is merely to lay the trail in a visible form, the actual substances which are to mark the transition to turbulence and the break-away of flow which follows over the wing surface being chlorine laid with the smoke trail and potassium iodide previously sprayed over the wing to be examined. After a few minutes wait for the trail to be stabilized, the experimental aircraft is flown through it and the wings on landing examined for the brown stain which indicates where the chlorine has been sucked in towards the boundary to react with the iodide. This is the region of the turbulent " boundary layer ", where too diffusion of the smoke takes place rapidly. (G. P. Douglas, Lecture to 7th International Congress of Applied Mechanics, London, 1948).

Near the walls of a wind-tunnel or water channel, or—thinking of the atmosphere—near the ground, the turbulence will not be isotropic, that is to say, the two cross components of turbulent velocity, one vertical (v) and one horizontally perpendicular (w) to the horizontal flow, will not be equal as they are at a point well clear of a solid boundary. The presence of the ground inhibits the vertical more than the horizontal cross-component. To exhibit this anisotropy of turbulence near the ground, two simultaneous photographs of a jet of smoke from a nozzle pointing downwind may be taken, one from a camera pointing vertically down and one from a horizontal aspect (Plate III). These photographs show a jet of smoke made by bubbling air through titanium chloride, going out through a horizontal nozzle 3 in. above a clipped grass lawn in the open. It is easy to see that the jet diffuses more rapidly in the horizontal plane so that a cross-section downstream is roughly elliptical instead of circular in shape.

During the war, the author assisted at a number of trials of smoke curtains laid from aircraft and noticed that one could learn quite a lot about atmospheric conditions at the place where the curtain was laid by observing the behaviour of the smoke. Firstly, its initial thickness is governed by the prevail ng humidity ; secondly, the persistence of the smoke is strongly influenced by the intensity of turbulence in the air, for this encourages collisions and consequent coalescence of the smoke particles until they are heavy enough to fall out of the sky ; finally, the drift of the smoke is an indication of the magnitude and direction of the prevailing wind. One instance of the third effect was so striking that the author preserved prints of photographs taken at the trial. These are now reproduced in Plate IV by permission of the Controller, H.M. Stationery Office.

It should be explained that a smoke curtain is produced by ejecting a liquid like titanium tetrachloride backwards from the aircraft at such a rate that the drops produced fall to earth, evaporating and forming hygroscopic nuclei as they do so. Their path is compounded of their gravitational velocity and the local wind speed. In the case cited a short curtain about 100 yd long was laid inshore from off the sea at Hayling Island, Hampshire, the successive pictures (Plate IV) being taken at intervals of one minute from the start of emission. One notices a line of fine particles which remain at aircraft level and continue after the main emission has ceased until the dregs in the container are exhausted. This line slowly thickens by diffusion as these particles are too small to fall under their own weight. The other feature is the drift of the larger falling drops in the wind which here takes the usual form of a rising onshore gradient from the sea up to 26 ft., but is there rather unusually followed by a *falling* gradient so that the whole cloud soon takes on the shape of an anvil. An anemometer on the coastguard's tower confirmed that at 25 ft the wind was about 20 m.p.h. but at aircraft height (50 ft) the drift of the smoke showed that the wind velocity had fallen nearly to zero.

The phenomenon occurred on a sunny spring day at noon and was the only one of fifty such curtains to exhibit this peculiar wind distribution.

A SUGGESTION FOR CHRISTMAS

To give our readers a chance of introducing *Weather* to their friends, we are making a special Christmas offer. On receipt of a completed order form, we will send five successive issues of *Weather* to any address in the world to which the magazine is not already being despatched. The first issue will be for December 1949, and we will arrange for it to arrive so far as possible during the week before Christmas. A card will be enclosed giving the name of the donor.

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ROYAL METEOROLOGICAL SOCIETY NEWS

FORTHCOMING MEETINGS

A meeting of the Society will be held on Wednesday, 16 November at 5 p.m. at 49 Cromwell Road, South Kensington. Papers by F. Pasquill on the measurement of temperature and humidity profiles and on evaporation from grass land will be read (printed in *Quarterly Journal*, July 1949); also a paper by C. S. Durst and G. H. Gilbert on calculation of geostrophic departures from observations of constant-height balloons.

A joint meeting with the Institute of Physics will be held at the Royal Institution of Great Britain, 21 Albemarle Street, London, on Wednesday, 23 November at 5 p.m. The subject will be "Atmospheric Pollution".

CENTENARY

In celebration of the Society's centenary a special meeting will be held on Monday 3 April 1950. During the preceding week there will be a conversazione, an excursion, and a series of scientific symposia, at which, it is hoped, a number of eminent meteorologists from overseas will be present. Further details will be published in the near future.

SCOTTISH CENTRE

The first meeting of the Scottish Section for the 1949–50 season will be held in the Department of Natural Philosophy, Edinburgh University, on Tuesday, 1 November 1949, at 5.15 p.m. Professor Gordon Manley will lecture on "Climatic Aspects of the Glaciation of Scotland". Tea will be served to fellows and their guests from 4.15 p.m.

MIDLAND CENTRE

A lecture will be given by Captain L. G. Garbett on "The history of the Beaufort scales" at Birmingham University, Edmund Street, Birmingham, on Tuesday, 25 October at 7.15 p.m.

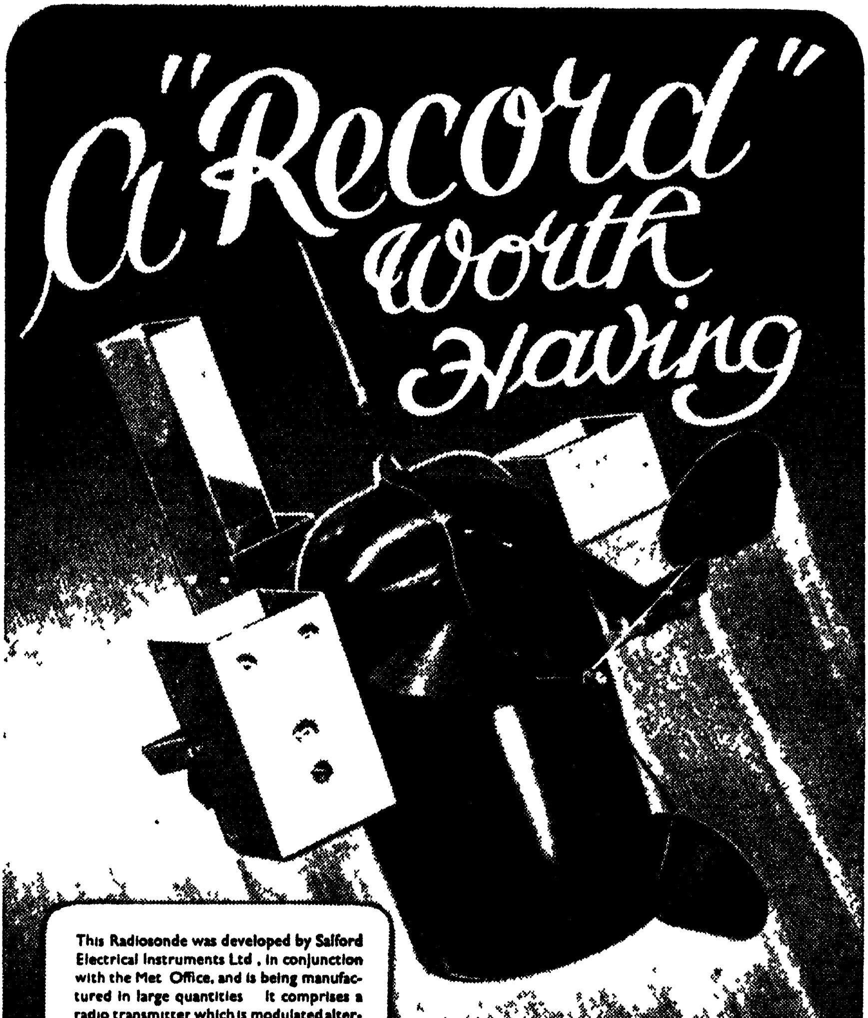
CHRISTMAS CARDS

The Society is arranging to print Christmas Cards for the convenience of Fellows, which will be available at 4s. for six (minimum order) or 7s. 6d. per dozen. The cards will be similar to those printed last year, except that the wording will be in brown and the photograph will be "Wind effects on snow in a railway cutting near Barras, Westmorland on 19 February 1947" (by courtesy of British Railways). Orders should be sent to the Assistant Secretary at the Society's offices, enclosing a cheque or crossed postal order for the appropriate amount. Envelopes should be marked "Christmas Cards."

CANADIAN BRANCH

On 28 April 1949, Mrs. Marie Sanderson, research fellow of the Ontario Research Foundation, spoke on "Potential evapotranspiration and the climate of Canada". The evapotranspiration is defined as the amount of water lost from land covered by vegetation and well supplied by water at the root level, and she described experiments in Canada to verify a formula proposed by C. W. Thornthwaite by which it can be calculated from the normally observed meteorological elements. The calculation can be used to derive the water requirements of irrigated crops, and experiments have proved its value. Calculated differences between rainfall and "run-off" from Canadian watersheds have also been verified.

Brigadier General D. N. Yates, Chief of the Air Weather Service, U.S.A.F., addressed the Canadian Branch on 26 May 1949. His subject was "Meteorological Service for the Berlin Air-lift". He described the organization of the air-lift which maintained a flow of aircraft at three-minute intervals along the air corridors to Berlin throughout the 24 hours. Operations continued during bad weather and there was a severe demand on the meteorological service which was called upon to forecast cloud height within 50 feet and visibility within one-eighth of a mile. In practice it was not found possible to attain such precision, even in the observations themselves. Improved instruments for measuring cloud height were devised and are now accurate to 20 ft or less for cloud base 100 to 800 ft; improvement has also been made in visibility-measuring instruments.



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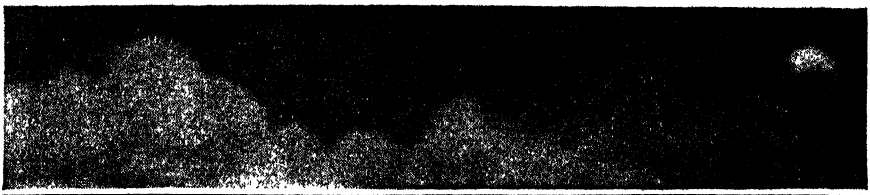

NOVEMBER 1949

WEATHER

Vol. IV No. 11

CONTENTS

EDITORIAL

Winter is just ahead and the period of low evaporation is upon us ; the ground will often be wet and the grass may not dry in the sun ; fronts may bring heavy rain : but these are factors which are apt to lull us into a false sense of security, for, unless we have a rainfall well above average this winter, we may have to be very much more careful with water next summer than we have been this year.

In *Nature* (Vol. 164, No. 4170, Oct 1, 1949, p. 554), Professor H. L Hawkins, whose article appears on page 366, outlines the history and geology concerning London's water supply He points out that the early founders of the city were more fortunate than they knew in their choice of location They relied on springs for their water but, as the city grew, in the nineteenth century, the art of well-boring developed and soon a great hidden reservoir beneath London was discovered At first the water from this came to the surface in many places under its own pressure in artesian overflows, but as the demand grew so the water-level sank. It then became necessary to pump all over the London area According to Professor Hawkins there are now 4,000 or more pumps in the Greater London area removing water from the Chalk (where the bulk of it accumulates) at about 260 million gallons per day, a rate with which natural replenishment cannot keep pace

Fortunately chemical means have been devised whereby the balance of the 568 million gallons, needed each day by Londoners, can at present be made up from the waters of the Rivers Thames, Lee and Stour Much of the water of these rivers is furnished by springs, but these are dwindling over a large area with the general lowering of the water-level in the Chalk.

Professor P. G. H. Boswell in his recent review of London's water-supply stresses that there is still much research, mostly geological, which should be done to make the most of our subterranean resources. In addition, as was recently suggested by Professor Gordon Manley in *The Times*, it may be necessary on an ever-increasing scale to bring water from distant sources as an alternative to storage over valuable agricultural land ; for, who can foretell the future demands of London's water consumers or the persistence or intensity of the dry trend in our climatic fluctuations ?

ON THE DYNAMICS OF CYCLONES AND ANTICYCLONES

By A. H. R. GOLDIE, D.Sc.

PART I

The article which follows is taken largely from four papers[1] prepared for the Meteorological Research Committee, Air Ministry, between September 1943 and December 1944. These dealt with air-mass transport generally and with the distribution of horizontal momentum and density, and the vertical circulations in cyclones and anticyclones. Partly, the object was to show the value of radio wind observations in throwing light on such a problem as the old controversy of 1915-18 on the dynamics of cyclones between Shaw and W. H. Dines on the one side and Aitken and Rayleigh on the other[2]. The discussions of 1915–18 arose from Aitken's thesis that his model cyclones produced in controlled air currents by the upward convection of warmed air, showed close analogies with the depressions of middle latitudes. The statistical results of W. H. Dines, namely that the troposphere is, on the average, colder, and the tropopause lower in cyclones than in anticyclones, appeared in the view of the meteorologists to make this convectional kind of theory " utterly untenable ".

In later years, even before the advent of radio sounding methods, meteorologists came to recognize that the statistical results of W. H. Dines were influenced largely by the conditions existing in old and decaying cyclones which may be relatively cold when they cross the British Isles.

It is now possible—by wind observations alone—to show, as Aitken 30 years ago was unable to show, that initially the air towards the centre of the active cyclone is of lower density than that in the outer environment of the cyclone ; and further to indicate something of the dynamics of the cyclone as a vortex.

VARIATION OF MOMENTUM WITH HEIGHT: CYCLONES AND ANTICYCLONES

The old " Egnell-Clayton law ", deduced from cloud observations, stated that there was on the average approximate constancy of horizontal air-mass transport—i.e. momentum per unit volume—at all heights.

The present-day radio wind observations enable us to approach this question with much greater precision. In the south of England, as represented by Larkhill, there is approximate constancy in the seasonal means of air-mass transport from about the 900 mb to the 300 mb level. In Shetland on the other hand this constancy obtains only in summer. In winter ρV reaches a maximum at about 4,000 ft.

The conditions in relation to the synoptic situation are interesting. Fig. 1 shows the mean wind speeds (V) and the mean momentum (in the form $\rho V/\rho_0$ where ρ is the air density at the level of V and ρ_0 is the density at normal pressure and temperature at ground level) under cyclonic and anticyclonic conditions respectively during the winter October 1941 to March 1942, using the data for Larkhill, Fazakerley and Downham Market.

Momentum shows approximate constancy with height in depressions from 2 to about 8 km, suggesting that the control of momentum is constant here. Below 2 km the conditions change steeply in the vertical. and this is in part presumably connected with the restriction of vertical movement arising from the fixed horizontal boundary (the ground) and in part with the convergence of air towards the centre of the depression which occurs largely in the lowest 2 km. The advantage attaching to ρV, as a factor for study, is that,

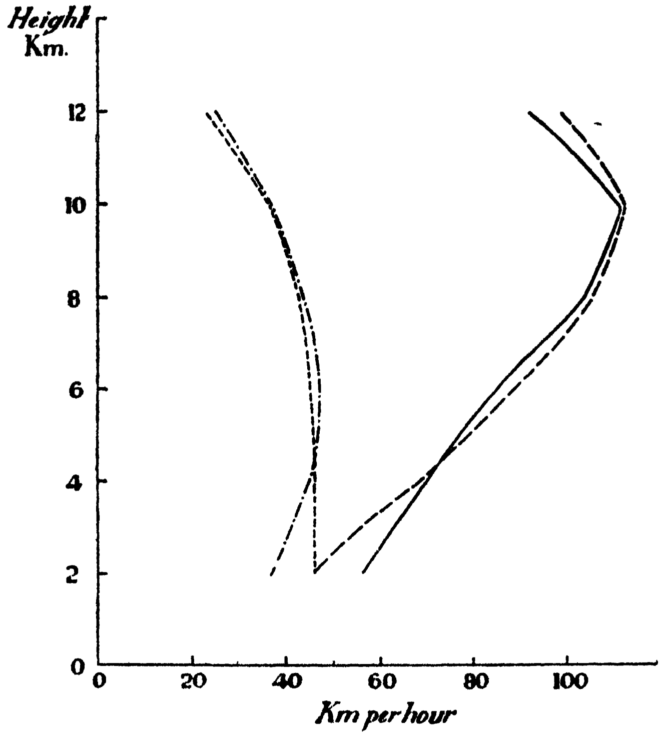

Fig. 1. Variation of wind speed with height in depressions and anticyclones
V ——— Cyclones — — — — Anticyclones
$\rho V/\rho_0$ - - - - Cyclones —·—·—·— Anticyclones

excluding cases of strongly curved trajectories, ρV is a measure of the barometric gradient: $\rho V = \frac{1}{2\omega \sin\phi} \frac{dp}{dn}$ with an accuracy which is probably of much the same order as the accuracy of measurement of wind or the determination of barometric gradient in the upper atmosphere.

Further, the rate at which barometric gradient increases with height depends on the rate of increase of density from the high towards the low pressure i.e. it is proportional to $\frac{p}{\theta}\left(\frac{\Delta\theta}{\theta} - \frac{\Delta p}{p}\right)$ where Δp, $\Delta\theta$ are the differences of pressure and temperature in the horizontal direction. Thus the variation of ρV

with height is a pointer to the nature of the change in density from the high to the low pressure region. In particular, constancy of ρV with height requires $\Delta\theta/\theta = \Delta p/p$ This relationship, $\Delta\theta/\theta = \Delta p/p$, means that, level for level, the air is colder towards the centre of the depression by an amount which considerably exceeds the adiabatic relation, $\Delta\theta/\theta = 0{\cdot}29\ \Delta p/p$. This in turn points to greater ascent of air near the centre of the depression than in the outer region. The values of $\Delta\theta/\Delta p$, (*a*) as computed from adiabatic relations, (*b*) as derived from the statistical average relations (all cases) of W. H. Dines, and (*c*) as estimated from the distribution of wind with height in cyclones in Fig. 1 are as follows (degrees C per mb) :—

	(*a*)	(*b*)	(*c*)
4 km	0·12	0·46	0·43
8 km	0·19	0·47	0·66

We deduce further from Fig. 1 that above 8 km and in the region of the tropopause there is also apparently not the same control as in the levels below; and the horizontal temperature gradients begin to reverse. The general distribution of velocities is in accord with a cell-like action in which the upward motion is mainly in the region from 2 to 8 km, whilst below 2 km and again above 8 km the motion in the cell is only horizontal.

ANTICYCLONES

Under anticyclonic conditions the variation of speed with height is similar to that in depressions in the region from 5 to 8 km, and also above 8 km. It is, however, only from 4 or 5 to 8 km that there is approximate constancy of air mass transport in anticyclones, and thus a connection between the horizontal gradients of temperature and pressure of the form $\Delta\theta/\theta = \Delta p/p$.

Since the level from 2 to 5 km is sufficiently high to be practically unaffected by surface friction, it may be taken that there is in this level a definite change in barometric gradient, i.e. the gradient diminishes from 5 down to 2 km. This means that, level for level, between 2 and 5 km, the air towards the centre of the anticyclone is very definitely warmer than that towards the outer fringes. It could be warmed purely as a result of greater subsidence near the centre, i.e., if it starts as a mound or heap of cold air, it apparently flattens down most rapidly in the centre. But a further point is that subsidence of air through a given distance will warm the air as a rule more than ascent through the same distance will cool air, since the former means rise of temperature according to the dry adiabatic and the latter in general involves fall of temperature only according to the moist adiabatic. It is chiefly this therefore that explains why in the anticyclone there is diminution of barometric gradient from 5 km down to 2 km (or lower) whilst this diminution is not shown in the cyclone.

The approximate equality shown in Fig. 1 in mean wind speed between cyclones and anticyclones above 5 km is rather remarkable but is, perhaps, accidental. The averaged surface-level pressures in the two groups of observations were 1007 and 1027 mb respectively.

The ascents made at Lerwick on disturbed days (wind exceeding 50 km/hr at the 950 mb level) were extracted January 1943, and separated into two groups—(A) those ascents made in front of a depression where pressure was falling, and (B) those made in the rear part where pressure was rising.

There were 23 ascents in category A, and 7 in category B. The ascents in each group had very distinct common characteristics, differing considerably from the average for cycloness at all times ; the mean curves for each group are given in Fig. 2. Curve A shows high momentum at low levels, and a

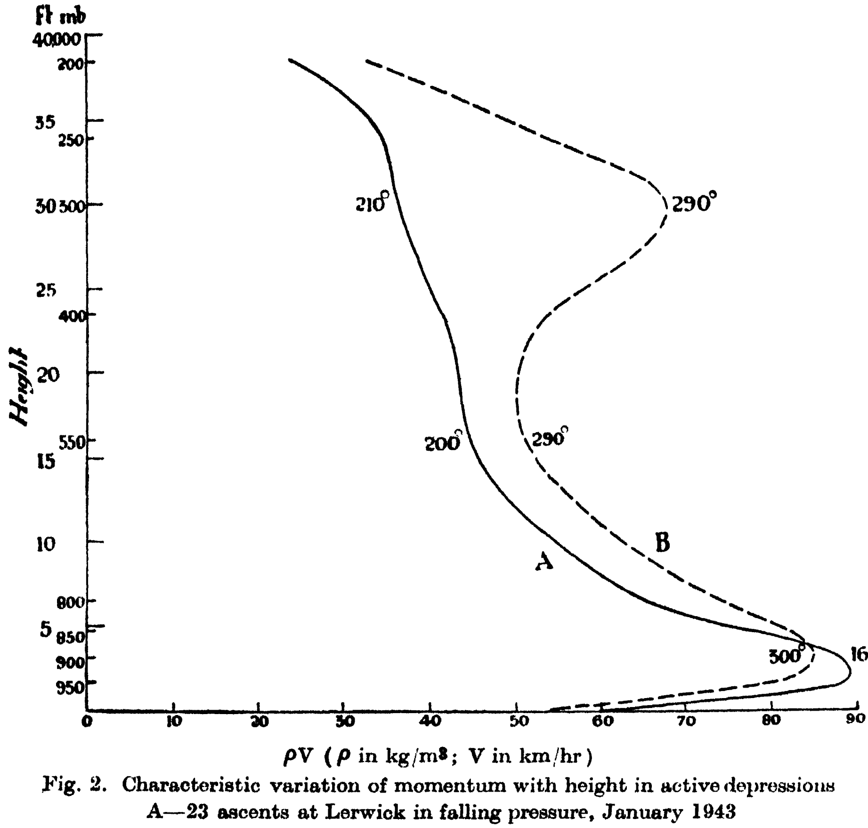

Fig. 2. Characteristic variation of momentum with height in active depressions
A—23 ascents at Lerwick in falling pressure, January 1943
B—7 ascents at Lerwick in rising pressure, January 1943

continuous fall of air mass transport with height from about 3,000 ft ; the fall is very steep from 3,000 to about 15,000 ft. The mean directions are entered on the curves. Curve A indicates that the air at a given horizontal level, particularly in the region from 3,000 to 15,000 ft, is much less dense towards the centre of the coming cyclone—i.e. towards the centre of the cyclone the isopycnic surfaces (of constant density) slope downwards.

Curve B (ascents after depressions have passed) shows nearly the same conditions existing towards the centre of the depression in the region from

3,000 to about 15,000 ft though with rather less decrease in density towards the centre. Above this height the turnover in the conditions is extremely interesting: the air in the centre of the cyclone above this height has now become more dense than the air originally there; the isopycnic surfaces are bulged up. Considerable adiabatic cooling in these levels would in fact be an inevitable consequence of the continued ascent of the air; and there is in some cases the further effect of advection of colder air.

Thus, far from the Rayleigh-Aitken thesis of initially lower density in the centre of cyclones being untenable, it appears, on the basis of the radio wind observations, to be characteristic of active cyclones that the air towards the centre is of low density up to 15,000 ft in relation to its isobaric level, at least initially though as a result of adiabatic cooling and, perhaps, advection, it may end by having a higher density.

The reasoning above is based on the assumption of at least rough geostrophic balance, but the above data are means for a considerable number of cases, and it seems scarcely likely that geostrophic departures could give a considerable mean departure in one direction.

The curves A and B relate to the front and rear respectively of depressions. It would be interesting to get the life history of one depression, but within the small area of the British Isles it is not easy to follow the same example for long. A number of other cases examined individually, some of depressions deepening, some of depressions filling up, suggest that the tendency is for the lower bulge of curve B to fade away, leaving at one stage only the upper bulge, which also diminishes as the depression fills up. The interpretation of individual cases, in terms of the pressure field is complicated sometimes by uncertainty as to the cyclostrophic element.

The existence of the air of lower density towards the centre of an active depression is not so easy to establish by direct temperature observations in that large depressions, which are mainly phenomena of the six winter months, never begin their development over the land areas; they are essentially phenomena of the ocean and in the absence (anyway until more recently) of upper air data from the Atlantic, it is only by computation based on variation of wind with height that we can establish the relative density of the air in the active or developing depression.

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   A. H. R. Goldie. *Variations of wind with height under cyclonic and anticyclonic conditions.* Air Ministry, London, M.R.P. 141.

   Radio wind observations applied to the discussion of the theory of depressions. Air Ministry, London, M.R.P. 163.

   The vertical circulation in relation to the momentum and density distribution in cylones. Air Ministry, London, M.R.P. 213.

2. A summarized account of Aitken's experiments and the resulting discussion together with the references is given in the introduction to *Geophysical Memoir*, No. 72, London, 1937.

This article will be concluded next month

EAST ANGLIAN FUNNEL CLOUD

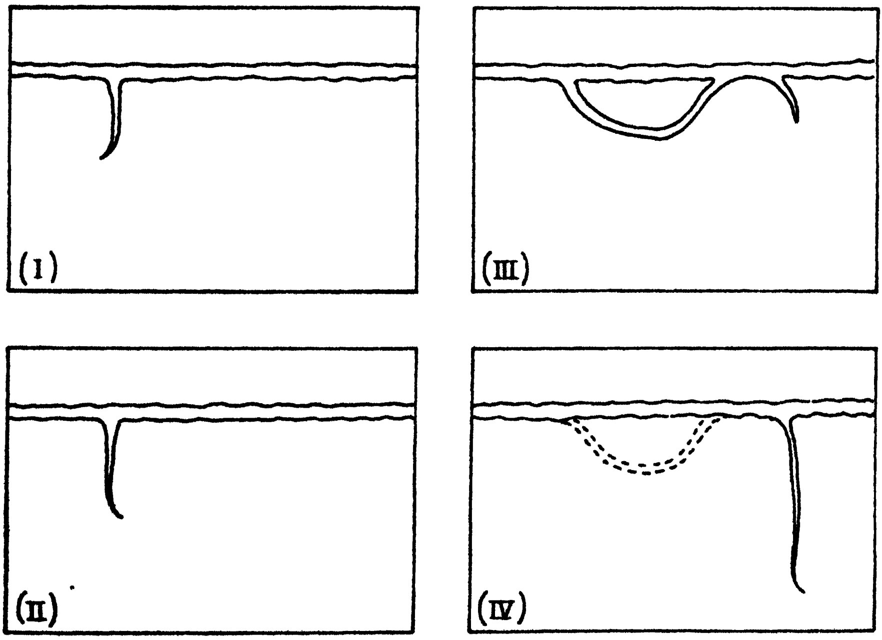
A REMARKABLE DEVELOPMENT OF AN UNUSUAL PHENOMENON

By C. M. Longcroft

On 19 June 1948 a polar depression, which had come during the last 36 hours from the west of Ireland, moved to ESE across North Wales into the Midlands. This depression then lost itself as a separate centre, forming a thundery trough from over NE. England down the Midlands and over East Anglia.

The air mass over these latter areas was very cold aloft with a freezing level of some 5-6,000 ft, and was inclined to be unstable. With the addition of gentle cyclonic convergence and strong surface heating, this tendency became greatly intensified resulting in vigorous shower activity breaking out during the late morning with a subsequent development of widespread hail and thunderstorms.

By 1300 GMT around Shotley, a small village to the south-east of Ipswich, thunderstorms were already in progress and a vigorous roll or squall cloud had developed from a massive cumulonimbus with a thunderstorm to the SSW of the area. This line of cloud stretched towards Ipswich and on it great convection and turbulence was in play. Along this line a number of embryo funnel clouds formed, but only one warrants mention by reason of the extraordinary characteristics it displayed.



At first this particular funnel formed in a downward path, then the tip twisted to the left (Figure 1) ; whereupon it turned back on its tracks to the right

(Figure 2), its central portion swinging back up into the base of the cloud, forming a great semi-circular loop, while the tip overlapped, forming a second funnel from where the centre of the tube had re-entered the cloud-base (Figure 3). The original stalk then quickly dissipated, leaving the old tip forming a new funnel (Figure 4).

The base of the squall cloud was at an estimated height of 1,800 ft and the second funnel (the longest of those seen) produced itself downwards to some 500 ft from the ground, steadily getting thinner and thinner and taking up a number of different shapes until it finally dissolved altogether at 1322 GMT, having been in existence for twelve minutes.

Within ten minutes of the dispersal of the funnel, a moderate thunderstorm had developed in the cloud mass above, which soon drifted over Ipswich.

As to an explanation of the extraordinary nature and behaviour of the funnel, it seems that the vertical convection currents both inside and beneath the cloud were so intense (as can be judged by the speed of the development of the following thunderstorm) that, when the funnel swung over to the right, its central portion, nearly down to the tip end, moved into and was caught by an exceptionally swift ascending current which carried it upwards into the cloud, leaving its extreme end just outside this current and so allowing its tip to continue development in the normal manner, but as a new system. It is quite natural that the old or original portion of the funnel should dissipate as the circuit of the spiralling air, of which it was composed, was then closed.

FANARÅKEN : THE MOUNTAIN STATION IN NORWAY

By Professor GORDON MANLEY

Many English and Scottish visitors to Norway have in recent years crossed Jotunheim by the Sognefjell road, leading eastward from the head of the Sogne Fjord past Turtagrö with its view of the magnificent Skagastolstind peaks, and thence ascending to nearly 4,900 feet along the northern foot of the outlying mountain mass of Fanaråken. Of those who walk or climb, a number must have visited that summit with its meteorological observatory, the highest in Northern Europe (61° 31' N., 7° 54' E., 6,765 feet). The accompanying photographs by Mr. T. Dick of Edinburgh were taken during a tour last summer, shortly before the visit by a group of meteorologists during their excursion following the International Geophysical Congress at Oslo.

Dr. Finn Spinnangr, director of the Bergen Meteorological Institute, presented the writer with a copy of the general account of the station published by him in *Naturen*, 1947. Observations on the summit were begun by Jon Eythórsson in 1922 in conjunction with Professor Ahlmann's nearby glaciological researches. In 1926 an observatory was built, but at first records were only kept during the summer. Gradually the building was enlarged and improved, and radio communication was established with Bergen. From 1 July 1932, the State took over and continuous records have since been kept.

Two observers live there for a year at a time, making and recording observations at three-hour intervals. A wind-driven generator, supplemented when required by an oil engine, provides current. Supplies were at first brought up on foot ; the climb from Turtagrö is reminiscent of that up Ben Nevis by the track, though it is steeper. A ropeway is now available for much of the distance In winter one or other of the observers may be able to descend now and then for a brief visit, if the weather is good, to bring up mail.

The general weather conditions are also reminiscent of those on Ben Nevis, but decidedly colder in winter ; and on the whole not so cloudy, neither is precipitation so frequent. Rime-deposit, however, is very heavy and often leads to severe icing-up of the instruments. Winds too attain great force so that the hut must be well anchored and protected. By February, the whole station, as Dr. Spinnangr says, often resembles a large sugar-icing cake.

The arrangement of the screen, in which the thermometers can be inspected from within the hut, will be noted. With the aid of large louvers and a north-wall position 8 feet above the ground the screen, I was informed, keeps tolerably clear. The Dines anemograph is very sturdy ; when necessary it can be heated by means of a blowlamp below and thus kept free from ice for most of the time. When very high winds and icing occur together the record is sometimes interrupted for short periods, following which the head must be taken down—not an easy job on an exposed summit—and the ice removed. More recently electric heating has been provided and works well if sufficient current is available.

The observers are sole occupants of the summit for about nine months ; from mid-June to the end of August the adjacent tourist hut, opened some years after the observatory, receives a good many passing visitors. The summit can be described as snow-covered on an average of 291 days yearly : July with seven and August with three days are the months of least frequency ; that is, from mid-June till late September the "ground" at the summit is more often bare than not. The corresponding figure for Ben Nevis is probably 215-220 days, the summit being generally bare of snow from the beginning of June to mid-October except for brief spells on a few scattered days.

The snowdrift in the photograph, beside the observatory, had completely disappeared when I visited the summit on 1 September 1947 after the phenomenally warm dry August, during which the mean temperature in upland Norway was about 8°F above normal. But in 1948 it was again persistent.

Precipitation measurements have been kept since 1932 but after some years it was decided to read additional gauges in different locations around the summit observatory ; from investigation it appeared that the first series of measurements should be increased by about 50% as the original gauge was over-exposed and not representative. It is now considered that the average annual fall amounts to about 68 in. (measured as rain). As far as we can judge after 14 years the rainfall is fairly evenly distributed through the months, May being the driest.

Sunshine is recorded at some time during 175 days, "wholly clear days" number 33. Fog is recorded at some time on 296 days, precipitation 264 (14 years' average). As regards wind, force 9 or more has been recorded on an average of 74 days yearly, force 8 or more on 117 days, 6 or more on 226 days. SW to NW are the most frequent directions, followed by SE. January appears so far to be the stormiest month, July the calmest, with 15·0 and 3·7 "days with gale" respectively.

Mean temperatures based on the 14 years (August 1932-July 1946) are quoted below with some Ben Nevis data (note for period 1884-1903) for comparison. It is probable that the mean temperature for Ben Nevis, 1932-1946 should be about 0·5° F higher taken over the year as a whole, than for 1884-

1903 ; this should be remembered when making comparisons.

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
1932-1946												
Fanaråken (°F)	9·3	9·9	13·1	16·9	24·8	32·0	37·8	36·0	29·1	21·6	16·9	13·5
Extremes so	35·4	32·4	35·2	42·8	50·7	55·4	62·4	59·2	54·0	45·1	39·7	33·1
far recorded	−25·8	−11·2	−10·8	−6·6	−6·4	10·0	20·0	17·6	−9·8	−4·4	−2·0	−14·1

Yearly Means : Temperature 21·7° F ; Rainfall 174 cm ; Days with snow lying 291

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
1884-1903												
Ben Nevis (°F)	24·1	23·8	24·1	27·6	33·0	39·7	41·1	40·5	38·1	31·4	29·0	25·3
Extremes	48	46	46	53	56	66	64	64	63	57	52	45
recorded	1	2	4	11	14	23	26	27	18	14	10	7

Yearly Means : Temperature 31·5° F ; Rainfall 408 cm ; Days with snow lying 225 (estimated)

One of the most interesting features of the Fanaråken climate is that a thaw, that is, temperature above freezing, has occurred and rain has been observed in every winter month, even at this altitude ; yet temperatures below zero have occurred in May. On the glaciers around the station the firn-line now lies at an average height of about 5,600 feet ; early in September 1947 it was a far above this, but on 9 September 1948 it was much closer to normal, following rather cool and cloudy August (early September 1949 was also near "normal").

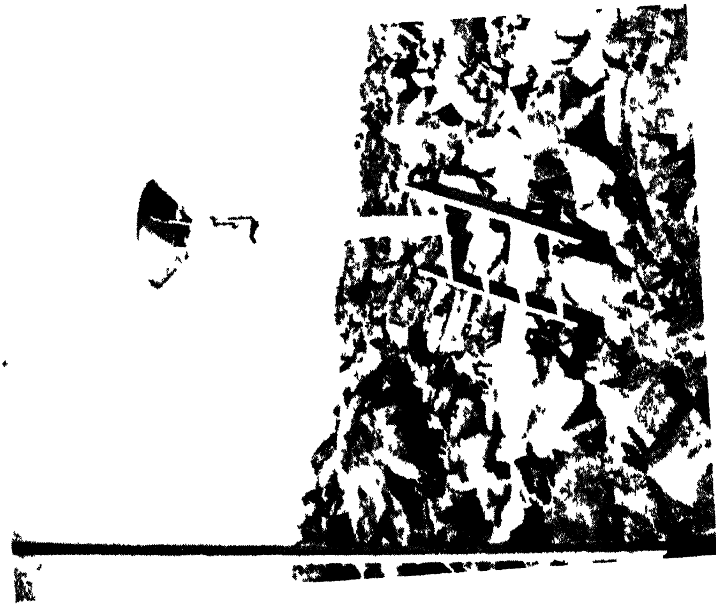
In 1947 a small Cambridge party crossed the summit after the tourist hut had closed, and it is a pleasure to recall the welcome and the cheerful " tea " that we received from the observers. We found them hard at work on their Diesel engine ; but it was not long before the kettle began to sing. The observatory is built high, so that the windows are not obscured by the winter snow. After climbing the outside steps we entered the living quarters through a double porch and the kitchen ; there is a sitting room about 16 feet square and each observer has his own small adjacent bedroom with a table where he can retreat to pursue his independent work. One was a keen radio-operator and had planned to carry on some private research during the long stormy winter. There appears to be little difficulty in finding observers. Perhaps this owes something to the Scandinavian university system which allows a student to work at intervals during his course of study, and something to the long-standing traditions of a seafaring nation which lead men to take a job far from home for many months. Maintaining the observations on the summit of Fanaråken is no light matter in the winter months, as the temperatures and the very high frequency of gales quickly remind us.

Fanaråken is the highest and most important of a series of highland stations whose reports are found to be particularly useful with regard to the operation of the Norwegian air lines. Mountain weather reports are also important for many other reasons, not least to the many Easter skiers. Dr. Spinnangr (with Dr. Odd Eide) has recently summarized the data from thirteen upland stations, at levels from 2100 feet upwards, in the 1948 volume of the *Meteorologiske Annaler* (Bd. 2, No.13 . . ." On the climate of the Lofty Mountain Region of Southern Norway ") ; this will be found useful to anyone interested in Scandinavian climate. The interest and utility of the records and reports from such a mountain summit as Fanaråken is such that many Scotsmen will wonder whether a Ben Nevis observatory might not be revived, lying as it does not far from a major air route. At the same time others would rather advocate a Cairngorm summit observatory ; such an institution would be of value to other scientists, such as botanists, and if a little simple accommodation were available such a building would be even more welcome and would contribute to its keep. Much can be learnt from even a brief sojourn on a mountain top and such a fixed station would be greatly welcomed by many university departments.

Faranåken: position of observatory shown by arrow

General view of Faranåken Observatory

Photographs by] [*T. Dick*



One of the containers for holding rainfall indicator basins Faranäken

Faranäken Observatory showing louvered screen and wind indicator

Photographs by] [*T Dick*

NOVEMBER RAIN IN DORSET

By Brian H. Mottram

[The original essay, entitled *Autumn*, of which this is a revised version, was written some eleven years ago when its author was still at school. At that time he could not have drawn the weather map (Fig. 1). This he added recently, after rewriting the essay. "It wasn't till *Weather* appeared", he writes, "that I learnt a fuller explanation of the whys and wherefores of the happenings described in the essay. I venture to think that some others as young as I was then would be more interested in meteorology generally if it was brought to them *via* English weather rather than Atlas climatology and school physics".

Readers may be interested to contrast his colourful account of warm-front rain with the succinct description presented by the weather map. Both describe aspects of the weather and each approach leads to a fuller appreciation of the other.—Editors]

The morning had been brilliant sunshine after another sharp night frost. It had pricked off the last coloured leaves from the trees. As I had gone up to "gym" along the back way above the hangings, the neighbouring wood had shed a golden rain from the chestnut trees mingled with a finer copper drizzle from the beeches. Earlier I had been sitting at work in one of the big front rooms of the school, where the warm sun streaming in through the big windows had lulled me almost into believing it was still September and winter ages away. This had been sharply dispelled however when I had looked down on to the terrace lawns below. They were carpeted with a thick layer of fallen leaves from the surrounding poplar and plane trees. The dark green grass was more than half hidden by a brown and yellow cover and displayed all too clearly the advance of the season; for it was now beyond mid-November. While the leaves still clothed the trees winter was far distant, but now with them spread in ruin upon the ground winter had leapt in at a bound and was almost here. It had been such a colourful autumn too, after the spring drought (April was rainless here this year) and the fine anticyclonic weather hung on very late. Yet the shortest day was only just over four weeks away. Now that the leaves had fallen there was no blinking the fact that winter had practically arrived. The bare trees would take some getting used to, but meanwhile everything was still. Not a bare twig or a forgotten last leaf had stirred.

Coming back to the main building down the other way after "gym", I could see away to the west over a side valley. I noticed that the sky had turned yellow along a sharp line above the downland sky-line. Was that the first sign of a depression coming and the start of the Autumn rains ? I hoped it was.

That afternoon I had free. Free afternoons were becoming rarer as I moved up the school and, as the town was out of bounds because of disease, I went for a short walk along the Gallop. This is a broad ridge separating two deep but dry chalk valleys that run down to the main river gap through the Dorset downs. The school building, a vast pile of red brick and Portland stone, stands on the end of this ridge above the main valley and commands a view in many directions. On walking west along this ridge, I quite quickly could see out over other neighbouring spurs for many miles around. I looked

up at the sky where by now a grey veil of high cloud had long ago blurred out the sun. It had been creeping over from the west all the morning. The crisp morning sunlight had dulled into a raw cold afternoon. The blue sky had long ago turned gradually through a milky white to the present grey. Above was grey and below was grey. The surprisingly black colour of the bare woods on the left-hand valley's opposite slope struck home the departure of the autumnal riot of colour that had let the last remnants of summer linger on so long this year. Against these dark woods a bank of blue smoke rested. It had persisted there from the bright morning to the dull afternoon unmoved.

I passed through the last gate which led me on to the Gallop proper. The broad ridge ran on to some copses about half a mile ahead. On its broad hogs-back the turf was interspersed with scattered hawthorn trees. These were now bare of leaves but were still liberally sprayed with clusters of dark red berries. One tree still looked surprisingly leafy and summery until a flock of starlings got up as I approached. Away on my right I could see out beyond the downs' edge, over the wooded vale to the dark hill on which Shaftesbury stands twelve miles away.

I swung my eyes round eastwards where, above the broad downland sweeps, I noticed the far-away edge of the cloud sheet. A narrow band of pale-blue clear sky showed above the grey fields and hedges rimming the eastern horizon. I looked up again at the hanging grey expanse overhead. I was reminded of Thomas Hardy's description of a white cloudy sky as a tent roof with the whole landscape beneath as its floor. I wondered idly whether he envisaged a sheet of high cloud or a blanket of lower cloud ; the latter was more likely, as it did not come on to rain later at night when the action of *The Return of the Native* is centred on Rainbarrow. This is an isolated flat-topped hill on Wareham Heath about ten miles south of the school—the heath is becoming known generally as Egdon Heath in consequence of Hardy's writings. It seemed this tent roof would pour rain down, not keep it out. Surely it must rain. I looked down to the west to see if the sky turned any darker above the copses at the end of the Gallop, or whether the slightly uneven hue of the cloud overhead became one shade of slightly lighter grey which usually denoted rain fairly near to.

Was this depression going to mock me and hang fire this time ? So often before they had misbehaved thus or dribbled a miserable amount of rain that had been of no use to anyone, let alone causing the school authorities to cancel games. which meant some extra unexpected free time. I always wanted free time and gladly grabbed it when it came, even if it meant a run first lasting twenty-five minutes, because afterwards I could always wallow extra long in the changing room baths. I looked hard at that sky low down in the west. Yes, that watery grey did show, and quite high up too. Rain was coming soon. Good ! Happy, I continued my walk a little further and remembered other correct forecastings of depressions and their results. Best of all I loved to watch a south-west gale rising all day and reaching its fullest fury as the dark came during afternoon school. Then it would drive sweeping veils of

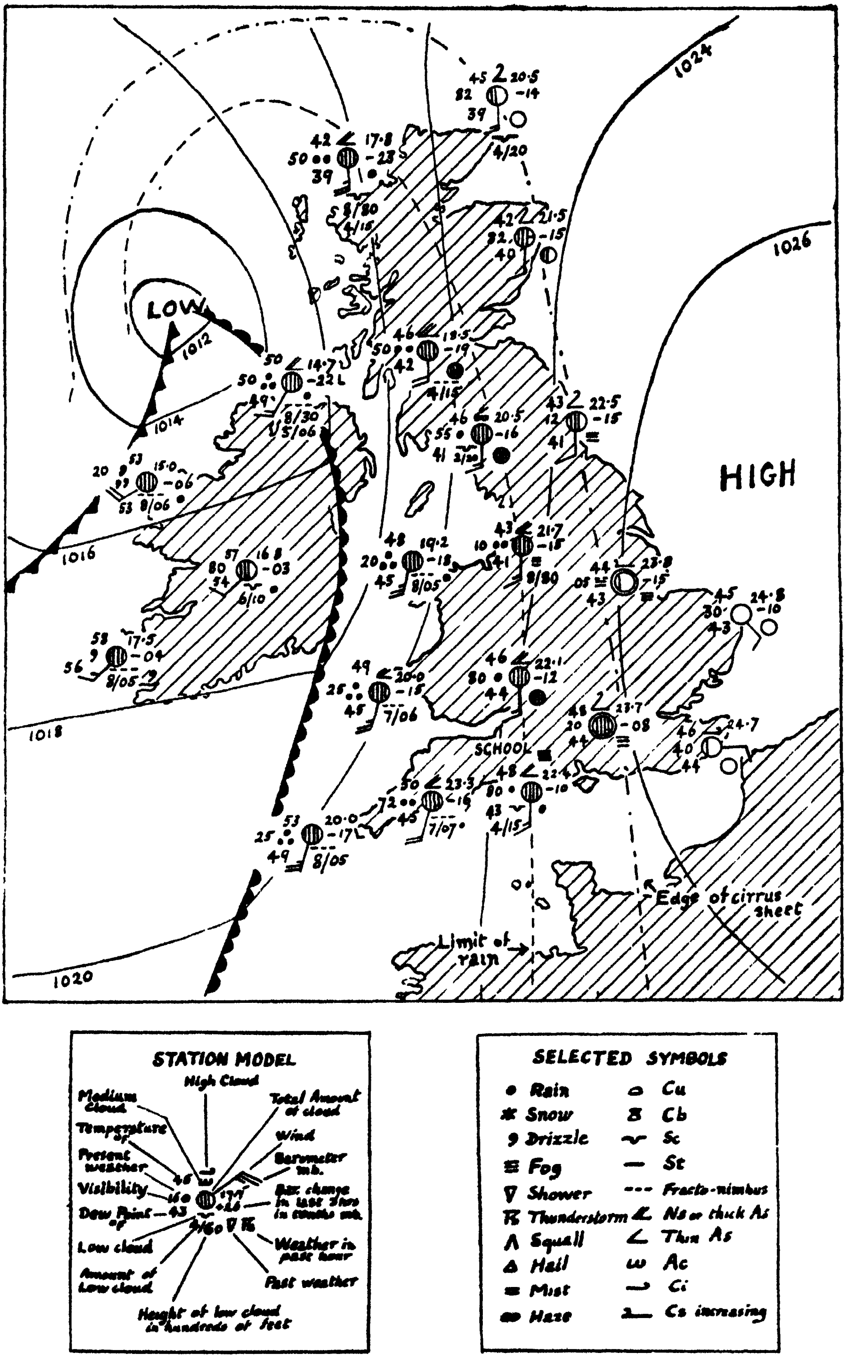


Fig. 1. Synoptic chart illustrating spread of warm-front rain from the west in autumn

rain across the valley and fling them furiously against the rattling huge sash windows of the building, whilst within all was snug and warm. It was all the nicer when, sometimes, on the impact of stronger gusts, the whole massive building shuddered and made boys look up. I often felt like grinning back at them from excitement.

But to-day there had not been any wind let alone any increase ; and yet the signs of a depression seemed just as certain. Both types were familiar to me and I was just beginning to wonder whether even this time I had been too confident when, quite unexpectedly, I felt the first drop. I waited for another. It came. Then another and another. Good—oh, good ! I was right after all. Very soon the ground began to hiss gently, as the rain increased.

The sky appeared just the same as before. No wind had risen and the trees stood just like rocks against the leaden sky. The landscape away down the main valley to the south-east began to blur as the rain moved across. Gradually the blue haze from innumerable chimneys of the little country town (two miles down the river) changed to grey. Nothing seemed to move anywhere except the practically invisible rain drops that fell steadily, and they increased imperceptibly all the time. The cattle, which had stood disconsolate by the gate below me as I came up, had long ago gone home to a group of long buildings deep down in the bottom of the left-hand valley, beneath the line of blue haze that still lay against the dark woods opposite. I knew this type of rain. It would go on for hours, probably long after dark, and would finally wash away any faint reminder of summer that had been so slow to die. I set off back along the ridge to that great pile of brick, stone and slate. It looked colder and bleaker through the grey mist of falling rain.

As I walked I saw far away across the main valley a field being ploughed. Bands of dark brown soil striped the golden straw stubble. As I watched a tiny black dot detached itself from one brown stripe and disappeared through a gate in the hedge. The tractor driver was going home. I hastened on back too. If I stayed out much longer, apart from getting the wrong clothes wet, I should begin to feel as miserable as the landscape around. All colour and life were draining out of it and dulling down to a drab monotone of grey. Yet at the moment I was feeling extremely pleased and happy. My forecast had come right. While walking it was not so very cold and the raindrops fell on my bare head with almost a caressing feel. I was not going to be out long enough to get to the uncomfortable stage when clothes begin to get wet but not yet soaked. I remembered that, strangely enough, getting thoroughly soaked was quite enjoyable. I was reminded of a certain run in the Autumn Term at my "prep" school on the Malvern Hills, when after about half an hour of being miserable getting wet, I began to enjoy things as the party, clothes soaking by now, squelched along a hillside path just beneath the low cloud base with the hill slope above lost in mist. That had been in warm, south-west rain. However, rain from the south-east is quite another matter. Almost invariably a south-east rain is icy, lasts all day and is heavy all the time. Getting wet in that is no joke. A January cycle ride across the Hampshire

Downs in those conditions was a sharp memory. There had been a wind then, too, which had made matters far worse.

By now I was nearing the school building and colour returned to the scene. Evidently the daylight was dimming considerably as lights were already on inside. They cast irregular and interrupted yellow paths across the growing pools and puddles in the tarmac of the drive in front of the school. As I came nearer circles of ever-widening ripples from impinging raindrops cast a constantly-moving mesmerizing pattern before me.

As I thought, it went on raining long after dark. I had to go up to the top of the building to get a book before darkness fell. It was still light enough to look out of the window straight down the ten miles of the lower Stour valley. Already the scenery was acquiring that wet, sodden look of a rainy autumn in Dorset. The sky and earth shared the soddenness. Ground, trees and clouds appeared unable to absorb any more moisture. Below on the leaf-strewn lawns, bare patches of earth, worn by tennis players back in bygone summer, glistened in the wan November half-light. The fallen host of leaves on the lawn, already soaked grey, had begun to provide food for worms and humus for next year. The haze on the wooded hillside opposite had become grey too as it gathered further mist about itself. There was still no wind, only the relentless fall of rain and the steady hiss of the falling drops upon the parapet outside the window and the louder patter resounding from countless boughs in the beechwood close by. I looked on down the Stour valley, over tree-tops, fields, houses and hedges and pieces of road to the line of heathy hills towards Poole. All these merged gradually into the grey haze and into the sky above.

In a class period before tea the English master gave out the week's written work to be done. Included was an essay on Autumn. " What a chance and coincidence", I thought. " Now I can write something I've long wanted to. I've got the material, too. I'm glad I *was* right about the rain. What fun this will be". Happy at the prospect of writing the essay during "prep", I went in to tea, jubilant and bursting within to get pen to paper.

The Sun's Year

This year has been the sun's. More than the years
Of all my life remembered. His the light
That cheered us through the seasons, till our fears
Of gloom to come dried like the dew in bright
Persistency. Before St. David's Day
The trumpets of the daffodils were blown,
Hedges were sprinkled white with April's may,
And June had never lovelier roses shown.

What if the life of lush green herbs is fleet,
And silent are our brooks and waterfalls ?
England has known at last the sun-god's heat,
For weeks undimmed by mist or cloudy shawls.
England has harvested rich auburn wheat
And sun-flushed fruit from sun-drenched garden walls.

G. M. Hawksley

MIST OVER ST. DAVID'S *

By F. W. M. Ruck

During 1942 and 1943 I was working near St. David's Head at the western extremity of Pembrokeshire. On several occasions the headland and surrounding area were quickly covered by a layer of low stratus cloud. The phenomenon was entirely local, the remaining countryside being in brilliant sunshine, the usual conditions being as follows :—

> A clear sky and SW wind of about 10 mi/hr, fairly warm. Stratus cloud would commence to form near the coastline, and, within half an hour or less, a continuous layer of cloud would cover the area and persist for several hours, usually forming in the early afternoon and clearing before evening, horizontal visibility (where the cloud reached the ground) being only a few yards. The disc of the sun could be seen for short intervals.

On one such occasion, a Flying Fortress flew into the top of Carn Llidi, a local hill ; there were no survivors.

As this cloud effect appeared to be a local phenomenon, I thought it was worthy of further investigation ; unfortunately, the War being in operation,

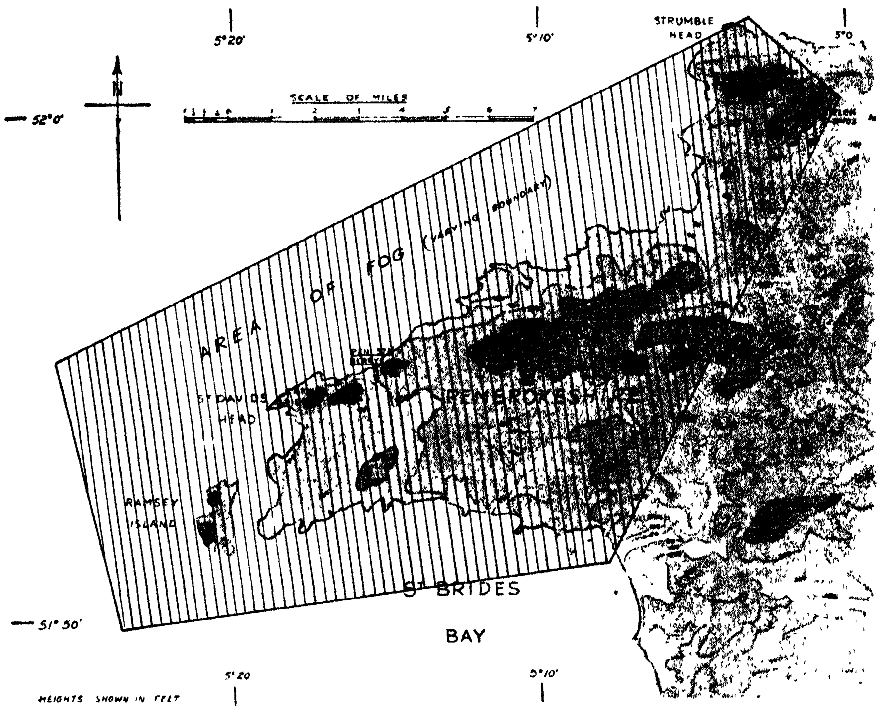


Fig. 1. Area of fog and St. David's Head

I was unable to obtain weather maps for these occasions. A glance at the contour map (Fig. 1) shows that the peninsula is about 10 miles long, 5 miles wide, and consists of a plateau varying from 200 ft above sea-level at the

* Prize-winning entry for Sir Napier Shaw Competition, 1948

Cliffs, to about 400 ft above sea-level further inland. There is also high ground exceeding 500 ft in height near St. David's Head and near Fishguard. The peninsula is open to the Atlantic Ocean.

A few weeks later the stratus began to form under similar conditions, so I cycled to the foot of Pen Berry, and commenced the climb through dense mist to the summit—573 feet above sea-level. Visibility was only a few feet, the grass and bushes dripping wet, and drops of moisture formed on my clothes and face. As I neared the summit I had glimpses of the sun, and when I was a few feet from the top I was in bright sunshine.

The contrast was remarkable. I was standing on a rocky " island " of about 30 feet diameter, surrounded by the billowing tops of white cloud. The sun shone from a blue sky. Two miles to the south-west was another small "island", the top of Carn Llidi. About three miles out to sea, the cloud abruptly ceased. To the north-east the summits of Carn Fawr, Carn Bolch and Bwlch-y-Rhos stood out above cloud-level. This appeared to be about the northern limit of the cloud. The mist extended for some distance over the sea in a southerly direction, the edge being very definite, as the details of the coastline at St. Anne's Head, 13 miles away, stood out very clearly in the afternoon sunshine.

The top of the mist was not flat, but fairly lumpy, some of the " cumulus heads " extending about 40 feet above the main cloud-level. Small gaps appeared now and then in the surrounding cloud and I could momentarily see fragments of fields about 300 ft below me. The sun cast my shadow on the cloudbank; it was sometimes about three times natural size (it varied with the cloud movement) and was surrounded by a bright light or halo effect.

I was suddenly enveloped in a billow of white mist, the sun disappeared, it was damp, silent, and quite cold—visibility being almost *nil*. After a few minutes the mist cleared from the summit and I was able to enjoy the scene again. I stayed there for an hour or more, and, although the wind was blowing fairly strongly, the area covered by the cloud did not appear to vary much.

I made several subsequent excursions to the top of Pen Berry under similar circumstances, and noticed that the phenomenon was very similar to that seen on the first occasion.

THE WEATHER OF OCTOBER 1949

UNUSUALLY WARM AT FIRST ; VERY WET FROM 16TH TO 26TH

The exceptional summer weather continued well into October, temperatures of 70° F occurring at many places in the South and East as late as 14th. Rainfall, except in the East, was considerable after the first week or so and restrictions in the use of water were generally removed by the end of the month.

Pressure remained high to the south-west of the British Isles for several days at the beginning of the month, dry and warm weather being the rule other than in the extreme North. By 5th a southerly type of weather was established. Thundery outbreaks resulted in fairly heavy falls of rain in the southern half of the country on 8th and 9th, and further rain fell on 11th after which there was another spell of warm and dry weather. Maximum temperatures again reached the 70's in the South and East and a minimum of 62° F on night of 14th to 15th at Kew equalled the record of 1921. By 16th a south-westerly type of weather had become general and rain fell in most areas nearly every day until 26th, this period proving to be the wettest of the year. On 18th a deep depression moving north-eastward over Scotland was associated with a widespread gale in which Channel crossings were the worst since early spring. Shoeburyness experienced its highest gust on record, 74 knots on 20th, while 49 mm of rain fell at Lympne in the 24 hours ending 0900 h on 21st. On 23rd a southerly gale caused considerable damage to the sea wall and other property near the front at Folkestone and elsewhere on the Kentish and East Sussex Coasts. The last depression of the series passed over the Midlands on the morning of 26th and heavy falls of rain and consequent local flooding occurred, St. Abbs Head, for example, reporting 59 mm in 24 hours. A ridge followed this depression, and by 29th an anticyclone was established over the Baltic ; quiet but cold weather, other than in the West, with fog in urban areas closed the month.

Our sympathy goes out to Guatemala where disastrous floods are estimated to have caused nearly 4,000 deaths, while 70,000 persons have been made homeless. Casualties, some fatal, were also reported early in the month from Southern Spain, and from a wide area east of Naples where storms have resulted in large-scale flooding.

	TEMPERATURE (°F)				RAIN (mm)*			SUNSHINE (hr)		
	Long period Average Max.	Long period Average Min.	This month Extreme Max.	This month Extreme Min.	Month	Diff. from Av.	Last 12 months	Month	Diff. from Av.	Last 12 months
Kew Obsy.	57·5	45·7	73	30	133	+71	483	115	+19	1786
Gorleston	57·1	46·5	74	30	61	—13	362	134	+19	1783
Birmingham	54·5	44·2	71	34	138	+67	673	96	+5	1567
Falmouth	56·3	47·7	†67	†40	193	+67	860	103	—10	2015
Valentia	56·5	48·8	69	36	253	+104	1377	69	—21	1404
Aldergrove	54·0	43·2	67	31	127	+41	740	68	—17	1358
Holyhead	55·5	49·5	69	37	137	+36	735	82	—15	1835
Tynemouth	54·6	45·3	68	32	61	—15	376			
Renfrew	53·6	41·9	65	28	159	+72	1078	65	—13	1429
Aberdeen	52·5	40·5	69	23	78	—6	674	104	+2	1562
Stornoway	51·7	42·7	61	31	123	—8	1141	52	—25	1279

* 25 mm = 1 inch (approx.) † The Lizard C.R.B.

METEOROLOGICAL DISCUSSIONS

LONG-RANGE FORECASTING

On 26 September 1949, at the Science Museum, Mr. J. Namias, chief of the Extended Forecast Section of the U.S. Weather Bureau, lectured on American methods of five-day forecasting. He explained that five-day mean contour charts of the 700 mb surface formed the basis of the technique. These charts brought into prominence a slow moving wave-pattern in the westerly wind stream of temperate latitudes with wavelengths of several thousand miles. The mean 700 mb chart could be forecast for the next five days by a combination of extrapolation and the application of physical and dynamical ideas. From this a mean surface-pressure chart was constructed using values for the air temperature below 700 mb, based on the normal values for the season and corrected in the light of the expected flow at 700 mb.

Statistical studies had shown the probable mean temperature and precipitation associated with particular flow patterns at the 700 mb level and, given the forecast 700 mb chart, it was now possible to draw objectively charts showing areas of the U.S.A. in which rainfall and temperature were expected to be in one of five groups—normal, above or below normal, or much above or below. These forecasts indicated trends and were of more use to farmers than picnickers. The accuracy of the forecasts was assessed by several methods; for example, 33% of the temperature forecasts were correct, as compared with the pure chance score of only 25%.

Mr. Namias presented his lecture in the most accomplished style and gripped the audience's attention throughout. He was obviously much more confident in talking about five-day forecasting than some of his colleagues were in issuing the forecasts. He attributed the following remark to Mr. Daking: "You need a very firm hand to draw these charts!"

INFRA-RED "VISIBILITY"

The transmission of the atmosphere in the infra-red region of the spectrum was the subject of a colloquium organized by the Royal Naval Scientific Service (RNSS) on 29 September 1949. The chairman, Dr. F. E. Jones, explained that there were serious gaps in the information available on this subject when work was started by the RNSS in 1945. Assistance was provided by officers of the Telecommunications Research Establishment (TRE), who later played a very active part in the investigations. The colloquium had been arranged to enable the results to be communicated to others concerned more quickly than was possible through the medium of published reports.

Mr. W. A. Gebbie of the RNSS described the instrumental arrangements. Measurements were made over sea paths of 2264 and 4460 yards between two headlands, using a Nernst lamp as source and a mirror arrangement by which the receiver, a spectrometer and thermocouple, could be at the same end as the source. Comparison observations were made over a path of 20 yards, and the whole system was calibrated against a telephotometer operating on a

wavelength of 0·6 microns (μ) in the visible part of the spectrum. Mr. W. R. Harding, also of the RNSS, described the operational technique. Absorption spectra had been measured over the range 1 to 13μ and more detailed studies of the effect of humidity and meteorological visibility had been made at four wavelengths between 2 and 11·5μ.

The results of the observations were presented by Mr. C. Hilsum of the RNSS and Mr. V. Roberts of TRE. Until the effects of the different reflectivity of the mirror at different wavelengths had been appreciated, some transmissions of over 100 per cent had been found ! The dependence of the transmission of different wavelengths on the meteorological visibility is shown in the following table.

Meteorological visibility (sea-miles)	Wavelength microns			
	0·61	2·18	3·61	10·01
2·8	25	55	69·5	(63)
5·6	50	73	81·5	83
13	75	85	95·5	87

Percentage transmission per sea-mile for different wavelengths at various meteorological visibilities

On wavelengths of 2 and 3·6μ the transmission appeared to be independent of the absolute humidity, but at 10 and 11·5μ there was a marked relationship, although with the limited number of observations available it was difficult to separate this effect entirely from the visibility effect. The absorption spectra showed numerous absorption bands due to water vapour and carbon dioxide and it was possible to identify some of the other bands as being due to some of the rarer constituents of the atmosphere, such as deuterium hydroxide at 3·67μ and nitrous oxide at 4·5μ. Above 8μ there was a complicated series of bands ; from a comparison of observations made with water-vapour pressures of 19 and 28 mm it seemed that most of these bands were due to water-vapour.

Professor Migeotte of Belgium described his recent measurements of the solar spectrum which he had made at Columbus University, Ohio. Detailed studies had been made for the first time of some of the bands in the infra-red and he was planning to repeat the observations at Jungfraujoch in Switzerland, where the effects of local industrial pollution of the atmosphere would be negligible.

Visitors afterwards had an opportunity, over a cup of tea, of discussing with colleagues what they had heard, and finally the instruments used in the experiments were demonstrated. The whole afternoon was very well organized and must have been an instructive and stimulating experience for all those fortunate enough to be able to attend. O. M. A.

EXPLORING THE THUNDERSTORM

The first of this season's Meteorological Office Discussions, held at the Imperial College on 3 October, was devoted to reports of the U.S. Thunderstorm Project, the main results of which were given in the article by Dr. Byers in *Weather*, July and August 1949. The opening speaker, Mr. F. E. Coles,

covered the same ground as Dr. Byers, and then stressed the significance of the findings from the point of view of the pilot. This aspect was dealt with even more vigorously by Wing-Cdr. S. W. R. Hughes, who had taken part in the investigations: he went so far as to say that the bogey of the cumulonimbus, the "killer-cloud" of war-time propaganda posters, had been laid and that, by following some fairly simple rules for flight procedure, pilots could fly through thunderstorms in safety, though not necessarily in comfort. He compared flying through such clouds to taking medicine, unpleasant but necessary, and producing the right results. Forecasters could help greatly to inspire confidence in pilots—and *vice versa*! He had heard of more than one gloomy-faced meteorologist telling a pilot how thankful he was to be staying on *terra firma* instead of risking his neck by flying when there were thunderstorms about.

The great interest aroused by these large-scale investigations was shown by the number of people taking part in the discussion; some thought that Wing-Cdr. Hughes was too optimistic and pointed to the dangers of hail and icing. Unfortunately much of what was said was only heard by people sitting in the immediate neighbourhood of the speaker because of a noise, even more shattering than that produced by the subject under discussion, emanating from a pile-driver assisting in the erection of an extension to the adjoining Science Museum. O. M. A.

ROYAL METEOROLOGICAL SOCIETY NEWS

FORTHCOMING MEETINGS

A meeting of the Society will be held on Wednesday, 16 November at 5 p.m. at 49 Cromwell Road, South Kensington. Papers by F. Pasquill on the measurement of temperature and humidity profiles and on evaporation from grass land will be read (printed in *Quarterly Journal*, July 1949); also a paper by C. S. Durst and G. H. Gilbert on calculation of geostrophic departures, from observations of constant-height balloons.

At the following meeting on Wednesday, 21 December papers will be read on the composition of coagulation-elements in cumulonimbus by F. H. Ludlam and on air motion ahead of warm fronts by M. K. Miles. Both these papers will shortly be published in the *Quarterly Journal*.

A joint meeting with the Institute of Physics will be held at the Royal Institution of Great Britain, 21 Albemarle Street, London, on Wednesday, 23 November at 5 p.m. when A. R. Meetham will read a paper entitled "Physics of Atmospheric Pollution—its balance with the atmosphere".

SCOTTISH CENTRE

A meeting of the Scottish Centre is to be held in the Department of Natural Philosophy, Edinburgh University, on Friday, 16 December at 7.30 p.m., when Mr. F. P. Henderson will talk on "Greenland Expeditions". Mr. Henderson has accompanied several Danish expeditions to E. Greenland as geologist. Among other things, he will describe the characteristics of the E. Greenland weather and unusual cloud and optical phenomena that he observed.

RAIN AND THE GEOLOGIST

By Professor H. L. Hawkins, D.Sc., F.R.S., F.G.S.
Dept. of Geology, University of Reading

The title of this article is not intended to imply any peculiar dispensation in the relation between rainfall and geologists. Statistics would doubtless show that rain falls impartially on them and other members of the community. Perhaps his preference for work in the field may expose a geologist to the rigours of the weather more often than those whose laboratories are indoors; but he differs in no way from his fellows in appreciating the amenities of a welcome inn after (not to suggest before) a thorough soaking. Unlike many addicts of the open-air life, however, his regrets at temporary inclemency of the weather are tempered by his realization that rain is the very life-blood of the world. Without it, no life could exist on land, and very little in water, and even the physical processes that maintain and reveal the course of geological history could hardly be achieved.

Leaving for the moment the question of the paramount importance of rainfall in the economy of organic life, it will be profitable to consider briefly its influence on the inorganic liveliness of the world.

The world can be considered as theoretically, and ideally, constructed on gravitational principles, being a series of aggregates of matter concentrically arranged with the density increasing inwards. On this plan, a "perfect" world would have its solid matter entirely enclosed in a hollow sphere of liquid which, in turn, would be entirely surrounded by the gaseous ingredients. Quite obviously the world is far from perfect in that sense. Nor is this imperfection regrettable, for perfection implies either stagnation or deterioration.

The "rinds" of the world are not sharply separated from one another, so that portions of the rocky material project through the hydrosphere to form dry land, while small particles of mineral matter may be whirled far up into the atmosphere. Similarly, water may soak far down among the rocks, and its volatility ensures that it will become a temporary part of the atmosphere. It would be a very curious specimen of air that did not contain appreciable quantities of moisture and dust.

RAIN, EROSION AND DEPOSITION

This mingling of the world's ingredients is temporary and inconstant, for the aim is always towards perfection. Dust and rain must both fall when the force of gravity can be brought to bear upon them effectively. The processes of mixing and re-sorting are for ever at work, and produce what may fairly be called the inorganic life of the world.

Rain (or its frozen equivalent) is the raw material of rivers. Rivers are the tireless transporters of rock-matter from high levels to lower ones and ultimately to the sea. Most of the rock-destroying agents, notably frost and chemical change, gain most of their effectiveness by the presence of rain-water, so that much of the material carried by rivers has been made portable

by the direct or indirect action of the rain. In a river the traffic is all "one-way". Even though the water may evaporate and climb into the clouds, the substances it carries, in suspension or solution, can travel downhill only. Molecule by molecule, grain by grain and ton by ton, the substance of the land is carried down to the sea.

The load on the land is perpetually lessened, and that on the sea-floor is correspondingly increased. If the earth's surface were ever in equilibrium, a shower of rain would disturb the balance and the process of readjustment would be set in motion. Overloading causes subsidence, and subsidence must, sooner or later, cause upheaval. Since depression and elevation cannot happen at the same time and place, the stresses drive from one area to the other, buckling the intervening rocks by lateral pressure. Doubtless the major regions of subsidence and upheaval owe their characters to deep-seated causes; but the differential loading due to superficial deposition and denudation is responsible for tectonic activity on no mean scale.

So rainfall leads to the accumulation of sediment, and apart from thus ensuring liveliness of the earth's crust, writes in it the greater part of the geological history of the world. Small wonder if a geologist watches the rain with appreciation rather than resentment.

WATER AND LIVING MATTER

Water is the chief ingredient of living matter: it is, indeed, hardly an exaggeration to state that life is a function of impure water. Of course, all depends on the nature of the impurities present, for some kinds of dirty water are lethal. Even in such cases, however, it is often a rival form of life, especially bacterial, that may prove fatal to the consumer.

For the denizens of the sea, lakes and rivers, living is a fairly simple task, although for most of them the vitalizing atmospheric gases must be available, and these are mainly brought to them by rain. But for the inhabitants of the land the acquisition and conservation of water is a most pressing problem. They have to catch the rainwater before it can return to the sea, and to ensure for themselves a perpetual supply, for they can live only by losing it. By breathing against a cold surface, it is easy to see that at every breath a measurable amount of water is dissipated, while violent exercise in hot weather may cause rivulets of perspiration to escape from all parts of the body. Every land creature, plant or animal, is gasping out moisture all its life, and its only hope of replenishment is, ultimately, the rain. Little imagination is needed to realize that the total amount of rainwater required to satisfy the vital functions of transpiration, respiration and perspiration is tremendous.

EVAPORATION, RUN-OFF AND PERCOLATION

When a shower falls on the land, three possible fates may befall the water. It may evaporate almost at once, it may collect into streams and trickle towards the sea, or it may soak into the ground. Although on the average these three options are fairly evenly balanced, there are many factors that influence their incidence. In hot weather the proportion of direct evaporation will

increase; on clayey ground that of "run-off" will predominate; while on sandy or other porous soils a great amount will soak in.

In so far as living creatures are concerned, the evaporating part of the water is virtually lost, the run-off part must be caught "on the run", while the soak-away part may linger as a reserve to tide over a rainless period. The soaking water may not get very far down, or it may reach great depths—it all depends on the nature and arrangement of the crustal rocks. Water that penetrates really deeply may, in course of time, re-appear as the explosive steam of a volcanic eruption, and during its sojourn in the realms of Pluto it may have engendered profound changes in the rocks by the processes of hydro-thermal metamorphism. The rainwater that soaks to a small depth may accumulate in bulk during the winter season; but in summer-time, when all the deciduous plants are in full leaf, it is caught by their roots and dissipated through their stomata so effectively that the "underground reservoirs" get little or none of it. So far as subsoil storage is concerned, a drizzly day in December is worth far more than a series of thunderstorms in July, whatever the rain-gauges may say.

MAN AND HIS USES FOR WATER

Of all terrestrial creatures, man is the most prodigal in his attitude to water. He has no personal aptitude for storing it, like a camel or a cactus; and he is so constructed that his body leaks at every pore. He is, therefore, an habitual and voluminous drinker. But the quantity of water that he absorbs is almost negligible when compared with his other demands. Most of his industries require, and spoil, enormous amounts, and the demands of domestic and personal cleanliness keep the taps running for a considerable part of every day. In spite of this, man is a most lamentably unclean creature, too often seeming to regard water as a convenient hiding place for garbage; indeed, in relation to water, man touches nothing that he does not pollute. Without elaborate precautions, rivers flowing through civilized areas may prove to be rivers of death rather than life-giving streams.

Herded together in thousands within his urban districts, man has made for himself the double problem of obtaining water in ample quantity and safe quality. By some means or other approximately forty gallons of pure water must be available for each person every day. This amount will certainly not fall perpetually as rain on the congested community; it must be brought from a vastly more spacious gathering ground.

RIVERS AND RESERVOIRS

If the source of supply is a river, the water must be filtered to remove silt, and chemically treated to make harmless the impurities (mostly of human introduction) with which it is impregnated. In a densely populated country most of the rivers, in their lower reaches, include the effluent from the sewage works of up-stream towns; this is a truly economical way of using the same water several times during its passage from the springs to the sea. It means,

of course, that such water, when suitably purified, is in reality a manufactured product.

Rivers are subject to seasonal variation of volume, and as a rule, their flow is at its nadir in hot, dry weather when the demand for water is at its zenith. Hence the impounding reservoir, preferably situated among the hills where the water is as yet very little contaminated. Most large towns are on the lowland plains, so that schemes of this kind require long pipe-lines with high capital and maintenance costs. It is, indeed, an expensive business to supply a large town with the amount of pure water that its inhabitants seem usually to take for granted.

River supplies, whether direct or by reservoir, represent an interception of the rainwater as it flows towards the sea; they may aptly, if punningly, be described as drafts on current account. But there is far more room below the ground than on it; and in the pores and crevices of the rocks is stored the accumulated capital of that part of the rainfall that soaks in.

RAIN AND THE GROUND

The uppermost few feet of the ground are alternately wet and dry, according to the prevailing weather; it is this vacillating condition that contributes to the crumbling of soil and subsoil. At a depth of a few feet (except on high ground made of sand or limestone) the rocks are permanently sodden. The amount of absorbed rainwater that they can hold depends mainly on the size of the spaces between their particles, so that really compact rocks contain very little. But it is generally true that the more compact in texture a rock becomes, the more profoundly it is broken up by cracks and fissures. So that clay, which is scarcely porous and too soft to crack, is almost the only kind of rock that cannot hold large quantities of water. Even clay is sodden, but its contained moisture is a fixed part of its substance, and can be removed only by evaporation or great pressure.

Through the pore spaces in such rocks as gravel or sand, and through the often cavernous fissures in compacted rocks, water can move with some freedom, provided that there is somewhere for it to go. In nature, this "somewhere" may be a spring-head, which serves as an overflow from the top of the underground storage. Artificially this condition is induced by wells from which the water is forcibly abstracted. Provided that the well is sunk below the lowest limit of normal desiccation, it will always receive water from its walls. The volume of its potential yield depends solely on the rate of the induced flow of water through the pores and fissures of the strata penetrated.

WELLS

In contrast to a natural spring, which is an overflow of surplus water from the subterranean "reservoir", a pumping-well draws its supplies from deeper levels, and so may continue to give a supply long after the spill-over from the top has ceased. The pump is draining the capital accumulation, and

(unless there is adequate income to offset the withdrawal) the process may sooner or later lead to bankruptcy. In many districts, notably in and around London, prodigal over-pumping from great numbers of wells has lowered the level of the water in the one-time saturated chalk so far that very many of them are now out of action. Expenditure has been in excess of income, as with so many of the human exploitations of natural resources. Elaborate calculations, by which an estimate is made of the quantity of rainwater supposed to be absorbed by so many square miles of catchment area, are of very slight value when applied to any particular place in that area, for the permeability of the strata is liable to extreme local variation. Every new pumping-station established for the public welfare may become, for posterity, a public menace..

POLLUTION AND SOLUTION

Water from wells is likely, subject to certain precautions, to be innocent of the pollution that is almost inevitable in surface water, but this does not mean that it is always a desirable beverage. Besides carbonate of lime and oxide of iron, which (in moderation) are useful tonics for the rickety and the anaemic, water dissolves some amount of almost every substance with which it comes into contact. Common and Epsom salt, lead, copper, arsenic and the like may make the well-water quite unfit for ordinary use, while "trace-elements" may induce goitre, caries and other regional diseases.

Here we revert to a fresh aspect of our main thesis. The solvent powers of absorbed rainwater are responsible, in the main, for the separation and segregation of the mineral ingredients of the earth's crust. The same rain that crumbles the stones and loosens the soil carries their binding materials below the surface, and with them converts sand into sandstone and ooze into limestone. World history is a record of the destruction and reconstruction of the stage whereon the water-filled bodies of organisms play their several parts. Whether it be the crumpling of a mountain range, the eruption of a volcano, the building of a delta, or the splashing of grit on to a newly-painted gate; behind every shifting of the scenery and every movement of the actors we can see the driving force that is inherent in a drop of rain.

HEREFORD SCIENCE SOCIETY

Readers may be interested in a lecture to be delivered on Thursday, 24 November, to the Hereford Science Society, by Cdr. C. H. Williams, R.N.R., Port Meteorological Officer, London. His subject will be the work of the marine branch of the Meteorological Office with special reference to the Atlantic weather ships. Particulars will be provided on application to the Secretary, Mr. R. Shaw Batchford (Tel. Ross-on-Wye 474), San Remo, Walford Road, Ross-on-Wye.

ERRATUM

Weather, July 1949, p. 231; at the end of the first paragraph please read 1·5 million years, not, as printed, 15 million years.

Strand-lines due to intermittent lowering of water level in reservoir: Woodhead, Longdendale, Cheshire

Alluvial delta of stream entering Bilberry Reservoir, Holmbridge, Yorkshire, at low water-level showing well stratified deposits laid down at high water-level. The stream has since cut through its old deposits

Photographs by] [*H.M. Geological Survey*

PLATE III

In the rear of a depression: Donhead St. Mary, Dorset, 10.20 BST, 2 June 1948
(see article on page 355)

Photograph by] [*B. H. Mottram*

Haboob at Khartoum, June 1948

Photograph by] [*S/Ldr. J. K. Kelley*

LETTERS TO THE EDITORS

The Formation of Duststorms

In an article " On the Genesis of a Dust Wall " in *Weather* of January 1949, Desmond and Radok give a most interesting report of a duststorm which occurred at Benalla, Victoria; and they show that the phenomenon was associated with local instability rather than with the passage of a cold front (which followed shortly afterwards). They refer to a local accumulation of cold air but say that the immediate cause is not clear from the observations. That violent duststorms may be results of local instability is well known, but it may not be generally realized that the cooling of air by the evaporation of rain is an important part of the process.

Some duststorms are associated with the passage of a cold front, but these may extend for many miles, whereas the dust wall associated with the cumulonimbus or thunder-cloud of local convection may extend for only a few miles spreading out fan-wise from the focus of greatest cooling. It is my experience that the local duststorm (dust-wall or dust-squall) with its buttressed curtain of dust or sand, is much more unpleasant and a greater hazard to aviation than some cold front duststorms—certainly more so than the ordinary dust-raising wind. An idea of what these dust-squalls look like will be obtained from the photograph in Plate IV of a Haboob at Khartoum. Haboob is the local name for dust-squalls in the Sudan.

Returning to the important factor of the evaporation of precipitation and the consequent accumulation of cold air and release of additional energy: in the Benalla duststorm it was observed that, initially, precipitation from the cloud did not reach the ground and that later, as might be expected, there was a marked lowering of the cloud base. Obviously much depends on the initial dryness of the air, but even when some rain reaches the surface, the down-draught of cold air may out-run the rain area with the result that the dust-squall precedes the rain or thunderstorm.

The presence of snow down to 2,000 ft as reported by Desmond and Radok is rather surprising in view of the fact that the surface temperature remained above 30°C and the freezing level was above 12,000 ft. Perhaps it was really soft hail that was observed ?

It will be realized that the forecasting of dust-squalls is not an easy task, for the forecastor must assess not only the extent to which there will be cumulonimbus development, but also the probable intensity of rainfall, its evaporation into the air below, and the direction of the squall.

Stanmore, Middlesex — R. G. Veryard

A Psycho-Physical Lunar Paradox

When the moon is eclipsed it looks like a football, that is it looks what it is—a globe. But the white daylight gibbous moon also looks globular in contrast to the yellowish night moon which appears flat. If the physicist says that the appearance of globularity is illusory and explained by light and shadow contrasts I believe him, but insist that he has not disposed of the matter or accounted for the awkward scenic fact that the moon in the specified circumstances looks what it really is. To force the issue: if the moon were a solid cube instead of a solid ball, would it then on occasion *look* a solid cube or continue to look globular ? My point is that anyone who attempts to resolve this paradox must exercise extreme care in his selection of words if he is to recognize all the facts, scenic as well as physical, and avoid quibbling.

Hampstead, N.W.3 — L. C. W. Bonacina

A Horizontal Rainbow

I have recently observed a horizontal rainbow. I had previously seen one in 1942 (*Quart. J. R. Met. Soc.*, 1942, Vol. 68, p. 296) and on that occasion the responsible water-drops were on a rough concrete surface. This time they were in an unexpected place, the surface of the evaporimeter. The phenomenon occurred at 0940h on 18 September 1949. A fairly thin layer of stratus formed about 04h and the sun broke through at 0920h and in its light a rainbow with faint prismatic colours was seen on the surface of the evaporimeter water when my back was towards the sun. On inspection, I found a thick layer of dust on the water-surface, and on this were large numbers of tiny water-drops floating, presumably deposited by the stratus some time previously. The phenomenon did not last long; the hot sun of this September day soon ended the existence of the drops, the diameter of which I estimated to be 0·5 mm. The theory of such bows is simple, and has been dealt with by W. J. Humphreys (*Physics of the Air*, 1940, p. 499).

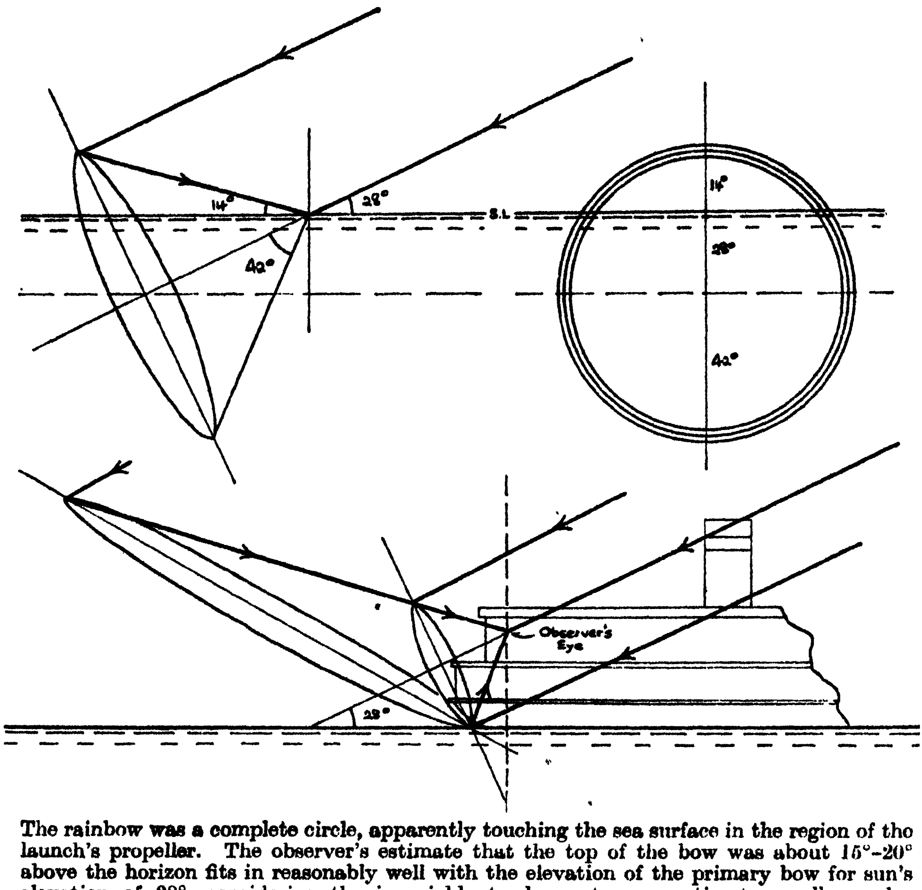
Wrexham — S. E. Ashmore

A Displaced Primary Rainbow

It was something of a coincidence that my June copy of *Weather*, which included Mr. Percy B. Ashworth's letter, arrived a few days after one of the Royal Observatory Technical Officers reported seeing a *complete* bow from the upper deck of a river boat.

The principle of Mr. Ashworth's Reflection Bow (as opposed to a Reflected Bow) is fully described in Humphrey's *Physics of the Air*, 1940 (p. 498) and the accompanying diagram is almost the same as the sketch in *Weather*. The complete bow observed by our Mr. Roland Hung, however, is not so easy to explain.

The facts, according to the observer's description, are as follows: At about 6 p.m. Hong Kong Summer Time, on 17 July 1949, the launch's position was 22° 12′ N, 114° 00′ E. The sun's elevation was about 28°. There were rain clouds to the S and SW, breaking up to the SE. From NW to NE it was practically clear sky. At the time of first observation the rain was estimated to be about three miles away. The wind was moderate SE'ly and the sea covered with small waves and quite unsuitable for the production of a reflection bow.



The rainbow was a complete circle, apparently touching the sea surface in the region of the launch's propeller. The observer's estimate that the top of the bow was about 15°-20° above the horizon fits in reasonably well with the elevation of the primary bow for sun's elevation of 28°, considering the invariable tendency to over-estimate small angular elevations. The rainbow lasted for 15 to 20 minutes, and, as Hung says, "disappeared when the rain caught up the launch". It appeared to be tilted away from the observer at an angle of about 60°, and *elongated vertically*.

Complete bows have been reported in the *Marine Observer* on several occasions, as for example, by Fisheries Cruiser "Freya" (Vol. IV, 1927, p. 170), s.s. "Frankenfels" (Vol. III, 1926, p. 58) and s.s. "Culebra" (Vol. II, 1925, p. 176); and in his article on "Rainbows and Fog Bows" (*Marine Observer*, Vol. XIII, 1936, p. 15) E. W. Barlow states: ". . . If the rain is near and especially if the observer is in an elevated position the bows will be greater than a semicircle and may even appear as complete circles . . . ."

In the present case the observer's elevation could not have been more than 17 or 18 feet. From the diagram opposite it would seem that reflecting drops for the lower part of the bow would have to be no farther away from the observer than a projected horizontal distance of about 7 feet (*i.e.* 18 tan 20°). Spray from the propeller might have been responsible for the lower arc of the bow, and it seems just possible that with the SE wind at the time rain was carried in advance of the rain-clouds on which the observer most probably judged the distance of the reflecting sheet. The plane of the reflecting droplets would therefore be tilted backwards from the stern of the vessel. Although this should still give the appearance of a circle to the observer, is it possible that the stereoscopic property of the two eyes could give an impression of vertical elongation if the reflecting droplets at the top of the bow were very much more distant than those at its base ?

Conditions for this phenomenon appear to be extremely critical and I am wondering if a complete bow has ever before been reported by an observer so near the water level and with so relatively high an elevation of the sun.

Hong Kong L. STARBUCK

Summer Evaporation, 1949

I was interested to see in a recent issue of *The Times* a reference made by the chairman of the Thames Conservancy Board to the extremely high rate of evaporation during the past summer. Records at Camden Square showed that the 1949 summer evaporation rate was the highest since records began 65 years ago, and that the total for July reached the record of 4·86 in.

I purchased a standard Piché evaporimeter last spring, and the period May to September inclusive recorded an evaporation of 20·32 in. The rainfall for the same period amounted to 5·78 in. or 52·7 per cent of the local normal.

The evaporimeter was hung in a screen which is situated in an exposed position with open fields on three sides and a large garden on the remaining side. The month of July recorded an evaporation of 5 67 in. which is understandable when compared with that of Camden Square since the latter exposure lies in a congested built up area with a restricted air circulation.

Ulceby, Lincolnshire P. C. SPINK

Rainwater Tanks for Gardens

In the early stages of drought a certain amount of water is wasted because the authoriti s delay putting a ban on the watering of gardens. Would it not be desirable for the authorities to warn the public that in future a ban will be imposed after, say, a week of fine weather, and to advise them therefore to instal rainwater tanks and to devise ways of diverting bath-water to their gardens ?

London, N.W.8 B. D. L. THOMAS

Significance of Freezing Level for the Occurrence of Thunderstorms

With reference to the article about Mr. Ludlam's review of recent work on ice nuclei in the December 1948 issue of *Weather*, I should like to send you a report of a remarkable small thunderstorm over the Hague in the evening of 1 June.

In the article it is said that Findeisen has put forward a theory of thunderstorm charge generation which implies that the charging is associated principally with the growth of solid particles of ice which are formed when the cloud cools below −32° C and Mr. Ludlam suggested that the essential difference between a shower-cloud and a thunder-cloud might be that in the tops of the latter the temperature had fallen below −32° C. The above-mentioned thunderstorm is very remarkable, as the cloud had reached a height very much below the −32° C level.

On 1 June there was a "col" over Holland and Belgium and the air was unstable in the lower levels. It was forecast, however, that there should be no thundery outbreaks as the unstable layer was not high enough for it. Indeed, though there were bulging cumulus congestus clouds throughout the whole day with tops estimated at 10,000 ft, no shower- or anvil-clouds were observed till about 19 h local time, when a small cumulonimbus with a flat top developed over the western part of the Hague. This was the only shower-cloud visible and the height of the top was estimated by me at about 15,000 ft. At that time I was at Leyden at a distance of about 10 miles from the Hague. The following day I got many reports from members of the physics undergraduates at Leyden, who are doing voluntary observations of thunderstorms, that there had been

thunder and a short shower of large raindrops over some parts of the Hague. Thunder was heard (at least ten times) and observers at Voorburg, where there had been no rain, reported vertical flashes between 1854 and 1915 hr. After this the storm travelled to the north-north-west and died out above the North Sea.

We cannot confirm or disprove from the Dutch upper air soundings our observations of the height of the cloud top, but even if it should have been 20,000 ft, temperature was still not lower than about $-26°$ C. At none of the 18 Dutch weather stations has thunder been reported. In this case the charging must have been caused by other effects (see *e.g.* the theories of Simpson and Wilson), and it should be interesting to collect more data of these small storms. More details of this storm will be sent to the Thunderstorm Census Organization in due course.

Leyden P. J. FETERIS

Intense Thunderstorms at Evesham, 13 July 1949

A short but very severe thunderstorm struck Evesham on Wednesday, 13 July 1949. It only lasted seven minutes, 3.03 to 3.10 p.m. BST, during which time 0·35 in. was measured, but for *one* minute at 3.07 p.m. I estimate that 0·20 in. fell. Perhaps you could give me your estimation when I quote the following: There was a sudden roar, and rain and hail fell with such intensity that visibility was reduced to less than 30 yards. I have scarcely ever seen a lower visibility in the densest of fogs. Other people estimated a visibility of only 10 yards, but whichever was nearer correct all agreed that they had never seen anything approaching such a downpour before.

It was extremely local, as a mile to the east and west there was no precipitation. No doubt this was the storm that reached Birmingham later in the afternoon, giving nearly an inch and a half in 40 minutes, but as the storm had by then spread in area it appears that the extreme concentration of rain had decreased.

Evesham, Worcestershire R. A. FIELD

Books Received

Annual Report of the Director of the Meteorological Office, for the year ending 31 *March* 1949. H.M. Stationery Office, 9d.

This describes the first full year's work since the reorganization (see *Weather*, November 1948, p. 325). The Forecasting Research Division at Dunstable under the leadership of Dr. R. C. Sutcliffe is undertaking an ambitious programme which includes both fundamental investigations of the physical processes in the atmosphere and the more practical objective of applying new discoveries to routine forecasting technique. The experimental forecasts for four days ahead are producing results which are "not discouraging", in which case there should be hope that they will be tried out on the public in the not too distant future. In the past, the Meteorological Office has been the butt of many unjustified adverse criticisms, but a recent letter in *The Times* and an enlightened article in *The Star* seem to indicate that the tide is turning. The public success of the four-day forecasts will depend very much on the way they are put over; no doubt advice will be obtained from the Government public-relations officers at the outset.

In the Central Forecasting Office at Dunstable a daily *post factum* examination of the 24-hour forecasts was maintained to determine the problems most commonly giving rise to errors. (*Post* takes the accusative, not the ablative, Mr. Director!) It is extremely difficult to assess the accuracy of a forecast on a percentage basis, but it would give the general public a very good indication of the improvement in forecasting if the annual report could include a statistical analysis of the results of the year's forecasts; even if there were some doubt about the absolute value of the yardstick employed, the relative figure from year to year should be of value. A. R. M.

Russian-English Dictionary of Meteorological Terms and Expressions, by W. A. Baum, 126 pages, Hobart Publishing Co. 1949, $7.50.

This new dictionary will naturally be compared with that published by the U.S. Weather Bureau in 1943. The most obvious difference is the increase in size, but a closer inspection shows that this is largely accounted for by a quite unnecessary duplication of terms. For example, the word for motion is repeated 35 times with such additions as "of air" and "of isotherms"—this one example accounts for nearly a page! No doubt some users will prefer this arrangement, but a British publisher would almost certainly have insisted on avoiding repetitions and such ordinary words as "pen" and "paper" which have no specialized meteorological meaning. This latter point was referred to in a recent Unesco report as a wasteful enlargement of a technical dictionary. So far as can be judged after a short period of use,the dictionary appears to be reasonably complete and up-to-date.

G. A. B.
O. M. A.

The Investigation of Atmospheric Pollution: *Twenty-sixth Report*, 125 pages, 10 figures, 14 tables, H.M. Stationery Office 1949, 2s. 6d.

The annual reports of atmospheric pollution investigations suffered the fate of many similar documents during the war of being temporarily discontinued, but fortunately the observations were continued and those interested now have the opportunity of studying the results for the five-year period ending 31 March 1944. In an introduction to the report, which otherwise consists largely of tables and figures illustrating the main results, the Superintendent of Observations, Dr. A. R. Meetham, points out that in spite of the war there was no general increase in the pollution of the air and suggests that the post-war rebuilding programme offers great scope for substantial improvement. It is to be hoped that the next quinquennial report will be pressed through more expeditiously than its predecessor, the preface of which is dated May 1947! O. M. A.

The Geology of Water Supply, by Sir Cyril Fox, 209 pages, 49 figures, 23 photographs, numerous tables, Technical Press 1949, 25s., inland postage 9d.

Concerning all that happens to rain after it has fallen, Sir Cyril Fox has behind him a store of authentic information based on the experience of 36 years' work. Using water supply as his main theme he discusses the whole story of water from the sea to the tap—from the moment water is evaporated from the ocean surface to form cloud and rain, through the rivers, reservoirs, wells and rock strata to the supply tunnels.

The book is lavishly illustrated with photographs, mainly of his own taking in India, and the various problems dealing with rock-structure are explained with the aid of excellent figures and tables.

Sir Cyril Fox frequently departs from his main theme, devoting many paragraphs to questions such as the action of water—erosion, transportation of sediment, tidal currents and waves—illustrating his points with descriptions of great floods and other spectac-

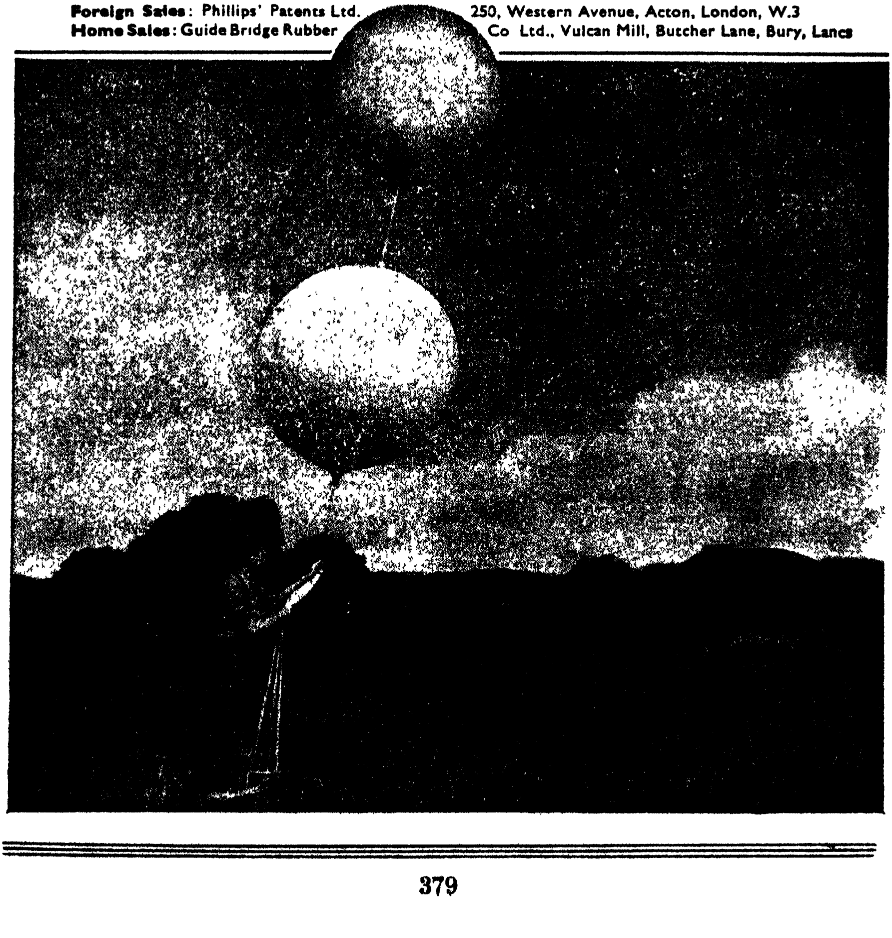
ular phenomena. He discusses, too, solution, organic pollution and the stability of hill sides with reference to landslides, subjects which lead him to the problems confronting the water engineers in the con truction of dams and tunnels. His meteorology is necessarily elementary, but apt to the subject of his book, and is essential to the story which he subsequently follows. It is undoubtedly a book useful to anyone interested in water supply. and would appeal to many others if somewhat technical in places.

C. D. O.

INSTRUMENTS, BOOKS, ETC., WANTED OR FOR SALE

WANTED

Good photographs of clouds and any other meteorological phenomena wanted for book illustration. Write author : Peter Hood, Waterpark Hotel, Sidmouth, Devon.



DECEMBER 1949

WEATHER

VOL. IV No. 12

CONTENTS

EDITORIAL

Much interest has been shown in S. E. Ashmore's article on the teaching of meteorology and the Editorial in October *Weather*, and various correspondents have made it clear that the last word has not been said. It is generally agreed that more people should know more about the scientific basis of meteorology, and that there are too few teachers and lecturers able and willing to help; but how and when this should be taught is less certain.

The vexed question of whether it should be taught in schools as part of geography or physics depends, surely, on the teacher. A geographer who makes use of the powers of his class to observe, deduce and imagine, and a physicist who can sketch in a wide background of meteorology before focussing attention on some example capable of physical treatment, are equally valuable They both have the difficult task of extracting or simplifying in such a way that the student does not feel that his new knowledge is merely a detached fragment, with no proper place of its own. We are grateful to a correspondent for drawing attention to the accounts of weather sequences in Herbertson's Descriptive Geographies; soon, perhaps, film strips and other visual aids will be widely used.

The course of 75 lectures outlined by James Paton in his letter, published this month, is doubtless of great value to degree students, but many of them would probably like to come back after graduating. Certainly, if the course were thrown open, it would attract many practising meteorologists of all ages.

The fact is that whatever the student knows of mathematics or physics, he can apply his knowledge to some aspects of meteorology; but there will be other aspects, necessary for a complete understanding of the subject, that are beyond him. This is true of all, from the arrogant teen-ager to the humble professor.

But at this season, much study is a weariness of the flesh. A Merry Christmas to all our readers.

CHRISTMAS DAY IN THE MORNING

By C. A. Wood

DRAMATIS PERSONAE

1st Forecaster
2nd Forecaster
Assistant, *meteorological*
Sheila } *Communications-sorting assistants*
Elspeth }
Toby Goon, *an electrician*
Ghost.

ACT I. Scene I.

Dunstable: The Central Forecasting Office

Enter two Forecasters, *and* Assistant.

1st Forec.: I take it, then, that we are at accord
Upon the situation? Frontal rain
Will reach all areas by nine o'clock.

2nd Forec.: No doubt of it:
The night is mild and, drawn across the sky,
A veil of cirrus blurs the pallid moon
With halo'd warnings. On the barograph
The purple trace declines; the wind begins
To moan i' the keyhole.

1st Forec.: Would that we could give
A different forecast. Christmas Eve with rain
Is sadly out o' season. At such times
My conscience and my knowledge 'gin to square,
And I would change the weather if I could
To joy the people.

2nd Forec.: Advective influence,
Before th' approaching vanguard of the trough
Brings damp and tropic vapours o'er the land,
E'en as was calculated. Hebrides,
Bailey, Rockall and Sole; all districts east
And south of line from Rattray Head to Mull
Are like to find the hop'd-for Christmas snow
Discandying ere morn. What is the hour?

1st Forec.: Seventeen hundred.

2nd Forec.: Time the tea was up.
[*Strides across the room to the communications-sorting hatchway, and shouts through it.*
Ho, there! Where is the tea? (*Aside*) Within me wakes
A sudden longing for the brimming cup
That soothes, and cheers, and not inebriates,
And quiets the groanings of the inner man.
The umber-colour'd brew from farthest Ind
Is long o'erdue. . . Ho, there! Our tea, I say!
[*Sound of feminine voices within.*

1st Voice: I attend, I attend, sir! The water is hardly boiled. A murrain on this griller; this is twice the element has burnt out. I'll have to get Toby to fix it again. Sheila, where is the sugar?

2nd Voice: I' the cocoa tin. 'Tis all we've got, so don't give those so-and-so's too much, Elspeth. We——

1st Voice: Shhh! The door's a-jar!

1st Forec.: The very elements do us despite
In divers ways, unless I hear amiss.
No tea as yet; what crosses we do bear!
Last week the ration fail'd; a power cut
Depriv'd us of it but a week before.

Now no hot water. Well, if we must wait,
Behoves it us to improve the shining hour.
You sir (*addressing Assistant*), to the enclosure take yourself,
And check the temperatures.

Assistant : As you command.

[*Exit, bearing electric torch.*

1st Forec. : I'll to the chief, to hold discourse upon
The latest observations for a while,
Until the kettle boils.

2nd Forec. : And I will see
The SFERICS man, while Elspeth brews the tea.

[*Exeunt.*

SCENE II. *The same*

Enter Elspeth *and* Sheila, *carrying three cups, a milk-jug, and a very large enamelled teapot.*

Sheila : The forecasters are out of humour tonight. Didst hear how they shouted ? What ails them ?

Elspeth : I know not. They are as grumpy as two misers with an income-tax demand.

Sheila : Or bears with sore heads.

Elspeth : The Christmas Eve forecast is a tricky one, I grant you—especially knowing, as I gather they do, that rain is coming in, when everybody wants snow. It is none of our doing, all the same.

Sheila : All afternoon they have stalked about like lions in a cage, calling for tea and observations. Oh !

[*Knocks over milk-jug.*

Elspeth : What hast thou done ?

Sheila : Quick ! The chart ! Mercy, look ! The milk has gone all over the chart. What a mess ! This will throw them into a fury !

Elspeth : Here is some blotting-paper ; mop it up.
Perchance 'twill not be seen ; or if it is,
They'll be too occupied to seek the cause.
Thus, thus, and thus—O heav'ns, a ghastly sight !
The ink hath run, and merg'd the symbols for
The past three hours into the lower cloud,
And the adjacent present-weather signs
Are quite washed out ; the rain at Blacksod Point,
Valentia and Shannon, now appears
As small six-pointed stars : the ten-knot winds
Have sprouted extra feathers——

Sheila : Hist ! Who comes ?

Enter Toby Goon.

Toby : By your mien,
Methinks you have some subtle game afoot.
Where are the forecasters ?

Elspeth : Gone out the while,
Pending the preparation of the tea.

Toby : And yet you guilty look ; a little flush'd
And furtive.

Sheila : Since you seek to know the cause,
We o'er the latest-plotted weather chart
Have spilt a jug of milk : added to which
The tea is hardly brew'd—no thanks to you
Who imperfectly fixed the element
On your last visit ; furthermore, the rain
That ever and anon threatens to fall
Across the British Isles for Christmas Day
Has put the forecasters in such a mood
As will not bear the reck'ning. This will be
The final straw.

Toby : I saw them as I came,
Stalking the corridors with furrow'd brow,
And in a sultry chafe.

Elspeth : What shall we do
To mitigate the retribution
That surely will descend when they return ?

Toby: Be quiet for a while, and let me think. They must be cozen'd out of their bad temper somehow. Hem! Especially since this is Christmas Eve.

[*Snaps his fingers.*

Of course! I have it!

Sheila: Have what?

Toby: A moment; I will return.

[*Exit.*

Sheila: The moon is past the full; it cannot be
That thus he is afflicted; yet he acts
In manner strange. Perchance he is in love,
Or else has look'd unwisely and too well
Upon a potent vintage.

Elspeth: More than like;
His nose a ruddy beacon shineth forth
On the headland of his visage, and his speech
Is somewhat slurr'd, like to the mumbling bee
That grubs th' exotic nectar from the flowers
Throughout the livelong day, to stagger home
Dazed and intoxicated.

Sheila: Yet must we
Be tolerant; remember Christmas comes
But once a year.

Elspeth: Once can be once too oft,
When such disastrous happenings attend
Its just occasion.

Enter Assistant.

Assistant: Yare, yare! The forecasters!

Elspeth: Out.

Assistant: But where?

Sheila: How should we know?

Assistant: I have news for them.

Elspeth: 'Twill have to wait; they will be back ere long for their tea.

Assistant: That will I, too. But for the moment; which of you
Will spare a lock of hair? The hygrograph
Has broken once again.

Sheila: Not I.

Elspeth: Nor I.

Assistant: One lock; one tiny lock. I do beseech——

Elspeth: Not one. You had two o' mine last week.

Assistant: In the cause of science——

Sheila: Go to; we are out of patience to-night.

Assistant: Good ladies, I pray——

Elspeth: Oh! Here, then; take it!

[*Snipping off a lock of her hair and handing it to him.*

Now be gone!

Assistant: I do thank you for your kindness.

[*Exit.*

Enter Toby Goon, *carrying bottle.*

Toby: Here's the remedy to cure their ills.

Sheila: What is't?

Toby: A rare and spirituous liquor
Call'd Scotch: once plentiful, and cheaply had
I' the golden days; now scarce, and highly priz'd
For export.

[*Removes cork and sniffs.*

Essence of ambrosia
Distill'd from honey-dew! A mortal shame
To waste such wondrous liquid on such men.
Yet—well, here goes! Peace and goodwill to all—

[*Empties a generous measure into the teapot.*

'Tis done.

Elspeth: Stop him!

Sheila: Too late a day, I fear; for he
Hath 'complish'd the fell deed. Calamity
Piles on calamity. Was ever such
A situation? Out with you, you rogue!

[*Drives* Toby *to the door.*

Toby: Help, ho! Desist, I say!

Sheila: Desist indeed!
I'll give thee such a buffeting to-night
As thou wilt long recall. Thou scurvy knave,
Take this—and this——

[*Exit* Toby *pursued by* Sheila.

Elspeth: O, I could give my woman's tears the way
And sit me down and weep. The happiness
Of this most happy eve has all turn'd sour,
Like to the cream that curdles 'fore a storm
And reneges the taste: I'll hence from here,
And in the traffic room disguise my fear.

[*Exit.*

SCENE III. *The same.*

Enter 1st and 2nd forecasters.

2nd Forec.: Nay, not so:
The SFERICS man was pale, and wild of eye,
Look'd earnestly, and swore upon his oath
To what I have forespoke; myself did see
Strange gleams and flashes i' the glowing square
He term'd the C.R. tube; shadows that cross'd
And burn'd a fiery green, or fluoresced
With snakish writhings o'er the gridded glass.
I like it not; my very grizzl'd hairs
Prickle like to the spiny porpentine
Unearth'd from's winter habitation.
This night will see some dark and dreadful chance
Visit itself upon us, or I err.

1st Forec.: Well, at least
Our duty nears its end; one forecast more—
The crucial one, and we depart this place.
Now to the tea—'tis ready, I perceive.
Woo't have some?

2nd Forec.: Indeed would I; my throat
Is dry and parch'd; sandpaperish it feels.
Here is my cup. [*Drinks.*
It hath a somewhat fragrant taste tonight.
Think'st thou not so?

1st Forec.: Peculiar. It courses through
My veins like quicksilver; catches my breath,
And yet is not unpleasing. Have some more.

2nd Forec.: I will.

1st Forec.: A special Christmas treat, I do not doubt,
Prepar'd for's by the girls; thus do they heap
Coals on our heads, repaying our churlishness
With care and kindnesses. Another cup?

2nd Forec.: Thanks, I will.

1st Forec.: We have been brusque with them this afternoon,
More than our wont; hereafter we must try
To make amends; two jewels such as they
Cannot be o'erpriz'd. A little more?

2nd Forec.: Hem! Just a tiny drop.

[*Sings.*

When the wind is in the east
'Tis fit for neither man nor beast;
When the wind is in the south,
It blows the bait i' the fishes' mouth.
When the wind is in the west,
Then the wind is at its best.
When the wind is in the north——

[*Stops.*

1st Forec.: Well?

2nd Forec.: I know not a rime for the north.

1st Forec.:	The north wind doth blow, And we shall have snow. Hem !
2nd Forec.:	Not so. The chart says it will rain. There's the rub. Thou'rt rather high-colour'd. Have another cup; 'twill cool thy fever.
1st Forec.:	All right. Now, where was I ? The north wind doth blow——

Enter Ghost.

Ghost:	Forbear !
1st Forec.:	Did'st say something ?
2nd Forec.:	Nay, not I.
1st Forec.:	I thought I heard a voice. Well, here's how !
Ghost:	Forbear !
1st Forec.:	O, look ! A horrid sight. What is't ?
Ghost:	Forbear !
2nd Forec.:	Who art thou ?
1st Forec.:	It does not answer: see How pale it looks; how lank and hollow-eyed; How wan; how, spectre-like, it glides across To th' plotting-bench, and hovers o'er the chart, Its lean and bony fingers beckoning Our presence there; speak to it yet again And ask what it requires. O, now I feel A strange distemp'rature assail my sense, And I am on a sudden something ill.
2nd Forec.:	(*To* Ghost) Say, who art thou ? What want'st ?
Ghost:	Ask not my name; the ghost am I of those Who in past years the Christmas forecast botch'd, And by the fierce and ravening multitude Were quarter'd limb from limb. This Christmastide, I come to save you from a similar fate If so I might.
2nd Forec.:	But how ?
Ghost:	Regard this chart.
2nd Forec.:	My vision is awry; the colours blur E'en as I gaze on them; and yet methinks I see snow symbols over Ireland, Ranging from Collinstown to Aldergrove.
1st Forec.:	Snow stars they are, and howling gales beside. What means this ? Whence this chart ? I never saw The like of it before; it hath a weird Unearthly look, as if the printed seas Had swept the printed land, and we behold The observations drown'd five fathom deep.
Ghost:	Waste no more time; go in for snow. Farewell.
1st Forec.:	Stay yet awhile, and tell us if thou canst, Where glean'dst thou all this strange intelligence.
Ghost:	I cannot stay. Go in for snow. Farewell.

[*Exit* Ghost.

2nd Forec.:	'Tis gone !
1st Forec.:	A fearsome apparition. My knees are weak, my head reels, and my teeth Chatter amongst themselves like castanets. Did'st hear the phantom say, go in for snow ?
2nd Forec.:	I did.
1st Forec.:	O God ! That one might plot the tephigram With radio-soundings of the after-times ! Extrapolate the pressure isopleths Along the future scale; tomorrow's obs, Bring forward to today; the gathering clouds That threat the sunny hours to come, mark out In clear-definéd lines, with Chinagraph Upon the prebaratic, knowing well The bounds to be observ'd. If one might this Accomplish, what a forecaster he'd be ! How high-esteem'd, how reverenc'd, how read In all the women's weekly magazines And Sunday newspapers, and picture-books

That circulate the globe ! Oh, such an one
Is needed here tonight ; would I were he !

2nd Forec. : There is a clue on each synoptic chart
Figuring the nature of the weather gone,
The which observ'd, a man may prophesy
With a near aim the shape of times ahead.
A tendency, perhaps, that shows a fall
Of pressure in a col ; a change of wind ;
A dewpoint out o' line ; a tiny kink
I' the isobaric pattern ; or a wave
Starting its progress from the U.S.A.
Along the Polar Front ; in the upper air,
A cool pool moving south. These things become
The powder and the trigger of the gun
Call'd labile entropy ; these we must read,
Set down, and learn, and inwardly digest,
If we would gauge aright. . . . But we delay ;
'Tis near five-fifty-five, and we as yet
No forecast have prepared. What shall we say ?

1st Forec. : Let me see.

[*Strides over to the doorway.*

Ho, there, signals traffic !

Enter Elspeth.

Elspeth : Did you call ?

1st Forec. : [*Seizing message-pad.*

This to all stations : snow and gales will sweep
Across the British Isles from out the west
Before the morn. The gales will be severe
In Shannon, Fastnet, Irish Sea and Thames ;
Winds backing east-south-east, and freshening,
Then veering northerly behind the trough.
Snowfall will be moderate, heavy locally
On higher ground. The cloud-base will be low,
Athwart the hills at times, and multi-layer'd
To twenty thousand feet. So send the word
With top priority to W/T.
Issue't on the Main Broadcast : pass it through
To Airmet, British Railways, B.B.C.,
And other normal channels.

Elspeth : As you direct. [*Exit.*

2nd Forec. : The die is cast ; all hangs upon this jump ;
Our very heads. If we prove out in this,
O what a fall there'll be, my countrymen !

1st Forec. : We shall not fail ; we cannot ; yet I own
A certain trepidation.

Enter Assistant.

Assistant : Sir, I pray,
A little of your time ; for as you bid
A while ago, I check'd the temperature,
And hasten'd back to tell—but you were out——

1st Forec. : Tell what ?

Assistant : Within the louvered Bilham screen
The silver mercury had fallen low,
E'en to the freezing-point ; and on the ground,
The dew had crystalliz'd to sparkling frost
Before an icy blast. The late reports,
Now coming from Rineanna, say the rain
That fell there recently, is chang'd to sleet ;
Birr Castle's sleet to snow ; look for yourself
If you believe me not.

[*Holds out a sheet of teleprinter paper.*

2nd Forec. : He speaks the truth.
These groups confirm the letter and the word
Of all he says. Among the late synops,
Sixes and sevens jostle cheek by jowl,
And snow falls ev'rywhere. O, what a sight !

[1st Forecaster *faints.*

Assistant : Alas ! He is dead !

2nd Forec. : Not dead ; 'tis but a swoon ; he will revive.
Give me a hand to bear him out o' doors.
This night hath witness'd curious happenings
Beyond the compt ; O, now we peering see
As through a cloudy glass ; our puny minds
Totter and reel 'fore Heaven's bright mysteries,
And our persisted hopes being fulfill'd
Affright the expectation.

Assistant : Yet 'tis not
For us to seek too deeply for the cause
Of what has come to pass ; let our relief
Ponder the reason for't. Will you away ?

2nd Forec. : With all speed.

[*Exeunt, carrying body. Flourish of Airmet bugle without. Enter* Elspeth.

Elspeth : It is not the fashion to see the lady in the epilogue, nor indeed to see an epilogue at all without a prologue. Yet am I come on behalf of the author to beseech your indulgence for his little fantasy, which he hopes may not prove displeasing to you, and to ask that you take it, as it was writ, in no too serious vein, particularly those of you at the Central Forecast Office, whom it so scandalously misrepresents, and for whom he has the greatest admiration. To you, and to such as have been so patient as to follow the play this far, I wish, on his behalf, a very happy Christmastide, and so doing, make curtsy and bid you farewell.

[*Exit.*

A SUGGESTION FOR CHRISTMAS

To give our readers a chance of introducing *Weather* to their friends, we are making a special Christmas offer. On receipt of a completed order form, we will send five successive issues of *Weather* to any address in the world to which the magazine is not already being despatched. The first issue will be for December 1949, and we will arrange for it to arrive so far as possible during the week before Christmas. A card will be enclosed giving the name of the donor.

Note the reduced price ; five copies of *Weather* for only five shillings !

To *Weather*,
49 Cromwell Road, London, S.W.7.

Please send *Weather* for the period December 1949 to April 1950 inclusive to :—

Name (BLOCK LETTERS)..

Address (BLOCK LETTERS) ....

....

I enclose the subscription of 5s. 0d.

Signed .... *Date*..............................

Address (BLOCK LETTERS) ....

....

CAMPBELL ISLAND

A SUB-ANTARCTIC METEOROLOGICAL STATION

By M. G. Hitchings

New Zealand Meteorological Service

In latitude 53° S longitude 169° E Campbell Island lies about 400 miles due south of New Zealand in the sub-antarctic waters of the great Southern Ocean (see Fig. 1). The island is 48 square miles in area and very hilly. The highest peak is just on 2000 feet and there are numerous others over 1000 feet with very few flat expanses of any extent (see Fig. 2).

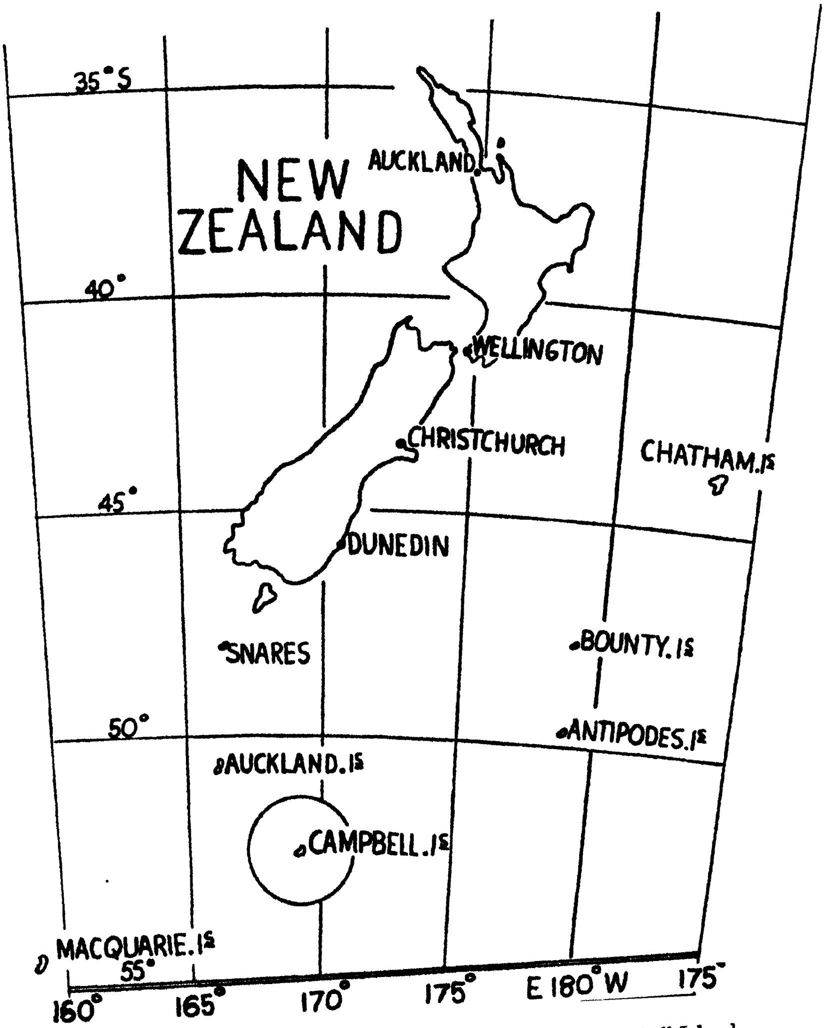


Fig. 1. Map showing relative position of Campbell Island

True soil, with the exception of some taken down from New Zealand for a garden, does not exist, the island being covered with a mantle of peat which supports a growth of tussock and wind blown scrub. The black aspect is relieved in summer by the brief flowering of plants surprisingly colourful for such a rigorous climate.

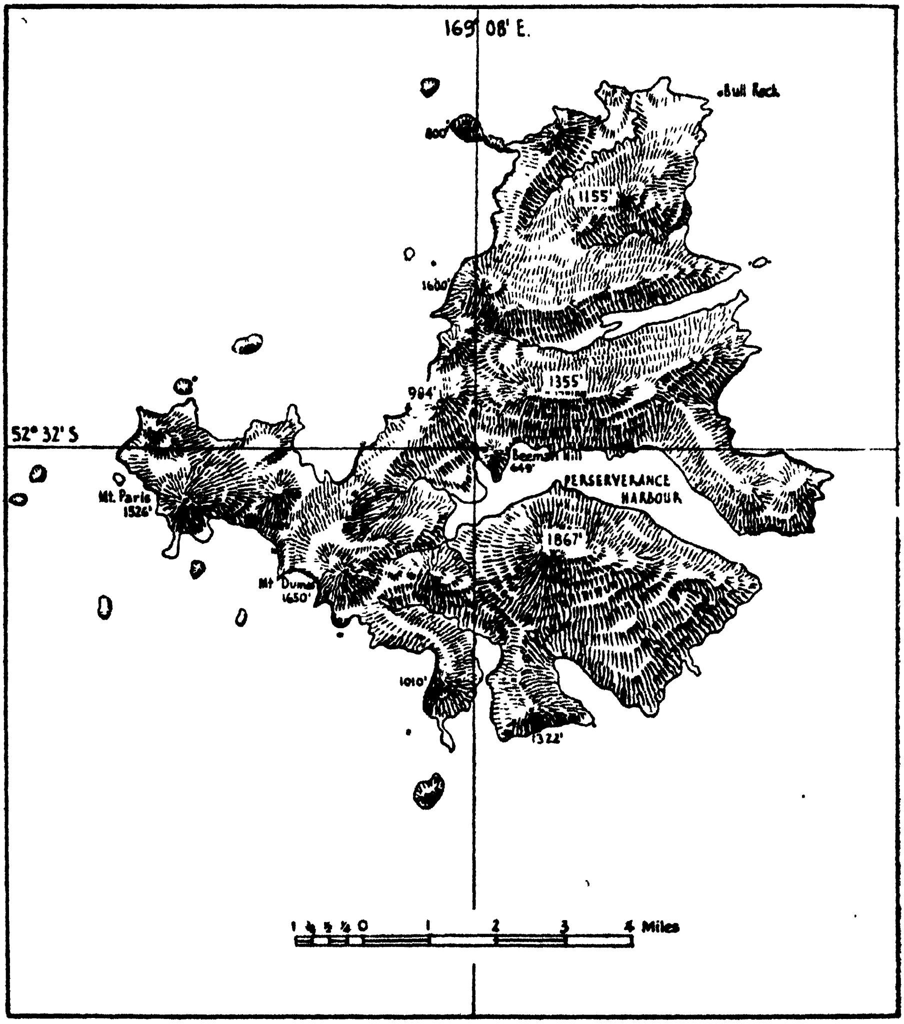
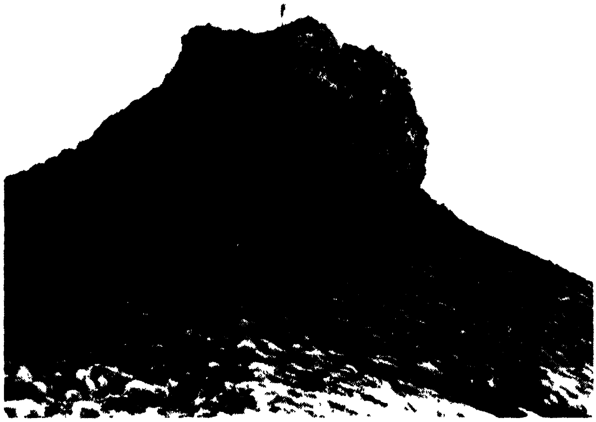


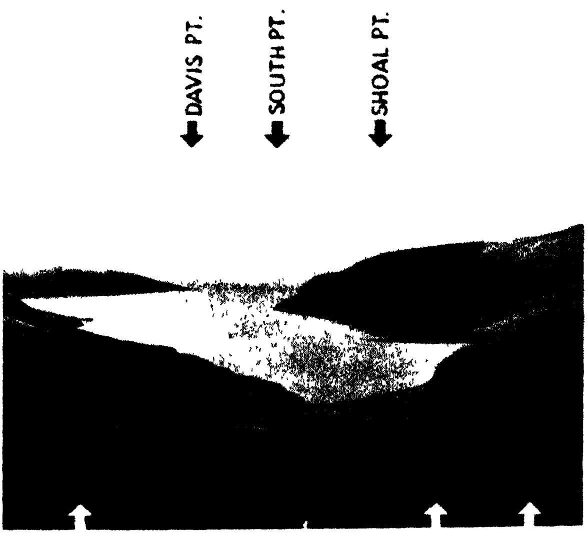
Fig. 2. Map of Campbell Island showing topography and highest points

In summer, too, the desolate surf-pounded coast becomes the scene of crowded seal " harems " and penguin " colonies ", immigrants returned from the sea for breeding and moulting, while the hills are starred with the white plumage of thousands of royal albatrosses and mollymawks. Of the four species



Col Peak showing anemometer on summit, Campbell Island

Photograph by] [*M. G. Hitchings*



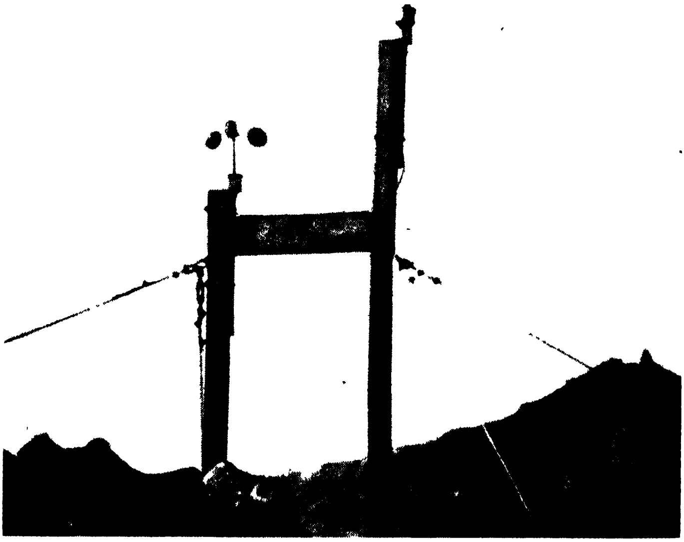
A B C

Entrance to Perseverance Harbour, Campbell Island

A = De la Vine Point ; B = Lookout hut ; C = Beeman Hill

Photograph by] [*N.Z. Meteorological Service*

PLATE I



Anemometer on Col Peak

Photograph by] [*M. G. Hitchings*

Sleepy Sea Elephants on Campbell

Photograph by] [*M. G. Hitchings*

PLATE II

of seals, the great lumbering sea elephant, up to 17 ft long and weighing several tons, attracts most attention, for he litters the landing beaches and makes the air noisome with his foetid breath. The millions of little Rockhopper penguins, always formally and immaculately dressed, provide much amusement for the observers stationed on this spot. The weather has played its part in moulding life on the Island, for many species of flightless insects are found, doubtless evolved as a protection against being blown out to sea.

ESTABLISHMENT OF THE METEOROLOGICAL STATION

In 1941, following enemy raider activities in New Zealand waters, the sub-antarctic Auckland and Campbell Islands were manned by small coast watching parties, to report any use of these Islands' excellent harbours by hostile vessels. The Auckland Island Group, also uninhabited, lie some 150 miles to the northwest of Campbell Island. This expedition, called the " Cape Expedition ", was carried out with the utmost despatch and secrecy and at first the parties on both Islands existed in complete isolation without even radio communication. As the war receded from New Zealand shores, however, the radio silence was lifted and synoptic reports were transmitted at regular three-hourly intervals.

In 1944, the Auckland Island stations were abandoned, but the weather reports from this general area had proved of such value that the establishment on Campbell Island has been maintained since then by the New Zealand Meteorological Service.

CLIMATE AND WEATHER

The following climatological information is based on observations during 1941-47. The rainfall on the Island is not high, with a yearly average of 57 in., but the number of days of rain (a day of rain consists of a measurement of 0·01 in. or more), 322 each year, is excessive. Much of the precipitation is in the form of drizzle from low lying stratus which explains the latter high figure in conjunction with the moderate rainfall. Little of the precipitation is accounted for by snow.

This oft-recurring stratus largely accounts for the low amount of sunshine recorded.

Table 1. *Average Rainfall, Raindays, Sunshine*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Rainfall in.	5·12	3·83	4·92	4·82	5·29	4·37	3·87	5·15	5·34	4·65	5·36	4·25	56·97
Days of rain	24	23	28	28	27	27	28	30	26	28	27	26	322
Sunshine Hours	88·0	84·3	66·4	43·2	25·3	12·0	16·8	29·5	54·8	73·0	95·8	95·7	684·8

The mean annual temperature is 44·2°F. The mean monthly temperature is remarkable for its constancy, the annual range (difference between mean

temperature of warmest and coldest months) being only 8·6°F. The extreme range (highest maximum minus lowest minimum) is 41·3°F.

The close relationship between the observations of air and sea temperature is shown in the following table. This may not actually be so close, however, as the sea temperature is taken inside the harbour owing to the danger in descending to the open coast.

Table 2. *Average Sea and Air Temperatures*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Approx. Mean Air Temp. ½ (Max. + Min.)	48.8	49·5	48·0	45·0	42·9	40·6	40·5	40·2	41·6	42·6	44·4	46·7	44·2
Mean Sea Temp.	48·9	49·1	48·8	46·5	45·3	43·3	42·8	43·2	43·7	44·0	45·7	47·5	45·7

Strong winds are very frequent. Detailed figures are not available as the camp was originally sited with a view to concealment and consequently the outlook is poor and the accurate estimation of wind strength difficult. Extremely strong NNW winds, however, funnel down the valley where the camp is situated in terrific gusts which have caused the barograph to pump as much as 5 mb.

A distant-indicating cup anemometer and wind vane has been installed on an exposed 1000 ft hill about half a mile from the camp, this unlikely spot being the only one that permitted of an unrestricted flow of air. Too unrestricted it has turned out, for the winds are so strong that the cups are occasionally blown off the anemometer and the average instrument lasts only six months before requiring major repairs.

AURORAL OBSERVATIONS

Campbell Island is in an extremely favourable location for observations of the Aurora Australis. One of nature's most beautiful manifestations, this

Table 3. *Auroral Observations*

Year	*No. Displays Observed*	*Year*	*No. Displays Observed*
1941	22	1945	22
1942	12*	1946	52
1943	42	1947	70
1944	12	1948	67+

* No observations available April to August
\+ Up to November 30

has been given close attention by the meteorological observers. Continuous logs of all displays have been kept, and these show a great increase in the development of form and intensity since 1946.

ON THE DYNAMICS OF CYCLONES AND ANTICYCLONES

By A. H. R. Goldie, D.Sc.

PART II

TROPOPAUSE CHANGES IN DEPRESSIONS

In Part I we considered the temperature and wind distribution in depressions. We now pass to considering the extent to which changes of temperature could be dynamical consequences of the air motion. Fig. 3 shows the upper air temperatures at 6h and 19h at Lerwick on 15 March 1943. Though an occluded front passed Lerwick between these hours there was no significant change in wind at any level and no significant change in temperature below the 700 mb level. The depression, however, became appreciably deeper between these two times.

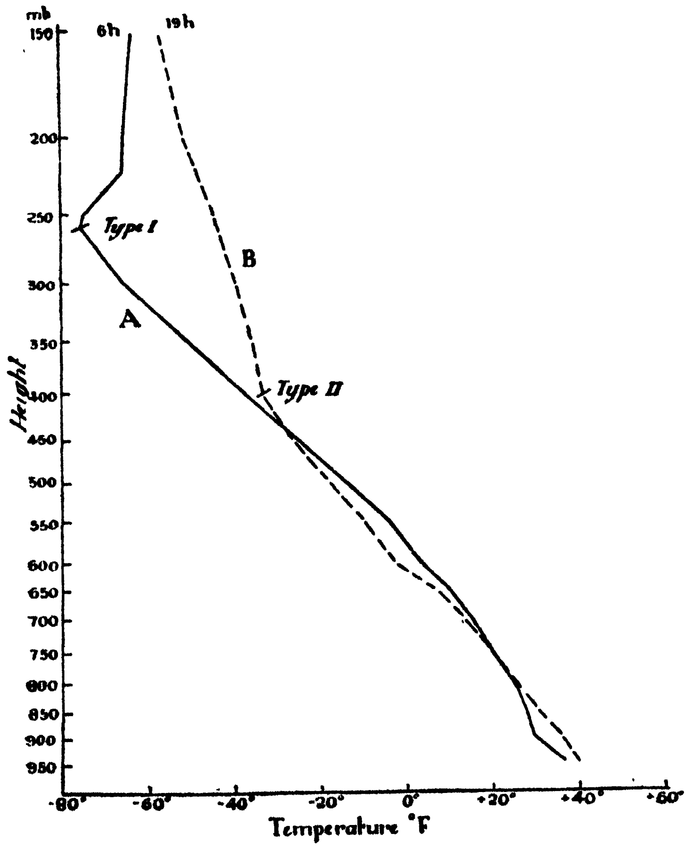


Fig. 3. Upper-air temperature at Lerwick, 15 March 1943, 06 and 19 GMT

One therefore inquires whether the distribution of temperature and the low tropopause in the second curve might be a dynamical product of the depression. In other words, what pressure changes impressed upon the air shown in curve A could turn it as a result of adiabatic changes into curve B ? The calculation has been done for the levels from 700 to 150 mb with the following results :—

Pressure level (mb)	150	200	250	300	350	400	450	500	550	600	700
Pressure change required (mb)	+9	+21	+59	+67	+42	+12	—3	—20	—24	—26	—10

This points to upward motion of air in the region below the 400 mb level and downward motion above that level. A comparison of curves A and B of Fig. 3 with this in mind suggests the following picture :—

(*a*) about half the air between the initial and final tropopause levels (250 mb and 400 mb) evacuated (presumably by horizontal divergence) ;

(*b*) the air in the troposphere ascending (by some 2,500 ft in the middle levels) and diverging under the tropopause ; temperature change would mainly be along the saturated adiabatic.

(*c*) the air originally above about the 330 mb level, i.e. mainly stratosphere air, subsiding and being filled in above to some extent by convergence in still higher levels, mainly above 200 mb ; temperature change would be along the dry adiabatic ;

Some further cases of depressions which were examined gave the same general picture of the changes in stratosphere and higher troposphere levels.

VERTICAL CIRCULATION BETWEEN CYCLONE AND ANTICYCLONE

One of the papers referred to in Part I (ref. 1) was devoted to the study of vertical cross-sections from high to low pressure using the data of temperature, humidity and wind from upper–air stations from Penzance to Lerwick. These vertical sections showed the existence of two circulations, one below about the 400 mb level—roughly the level of quasi-constant air density—and the other above this level, running in opposite senses as if geared into one another. In the low pressure there was ascent of air in the troposphere, subsidence of air in the stratosphere. But in the high pressure there was subsidence of air only below the 400 mb level. Above this level in the troposphere there was ascent; and in the stratosphere above the high pressure there was also ascent, with, it is estimated, conditions of saturation in the lowest level of the stratosphere. The horizontal convergence and divergence at different heights, as computed from the radio wind observations, is shown in the paper quoted and is in accord with these vertical movements. The diagrams are not reproduced here but Fig. 4, relating to the period of 9 March 1943 20 h GMT to 10 March 20 h GMT, and deduced from a pair of diagrams in the paper, shows the changes in potential temperature between situations separated by 24 hours, during which a depression centre passed roughly along the Arctic Circle deepening slowly in the interval.

The arrows show the principal regions of ascent and descent. The figures entered alongside them are the estimated amounts in feet of ascent or descent required to account for the changes in potential temperature in the 24 hours to which the changes relate. The only part of the diagram in which temperature changes due to advection introduced a complication was in the northern end, in the troposphere. The ascent computed here is that estimated as being required to account for changes in air temperature additional to those connected with the change of air supply.

TRANSFER OF THE PRESSURE FIELD UPWARDS

Consider again now the results relating to momentum. It was seen in Part I that the air towards the centre of the active cyclone is of lower density than that in the surroundings of the cyclone; also that characteristically the cyclone develops first as a whirl of maximum momentum in the lower levels of the troposphere; then the tropopause is lowered whilst the high momentum is transferred to the upper half of the troposphere.

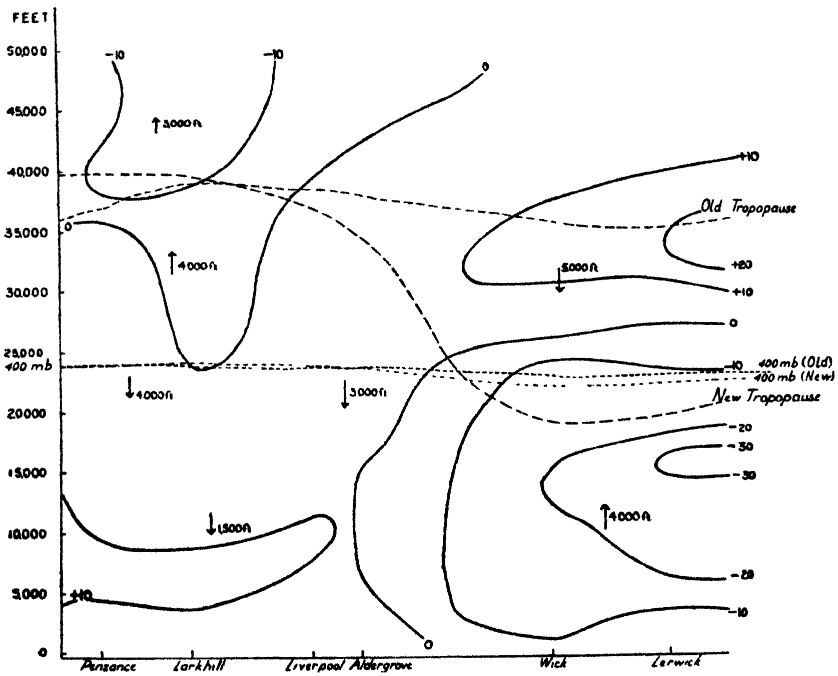


Fig. 4. Change in potential temperature from 9 to 10 March 1943

Though it is possible that the transfer of momentum from lower to higher levels is accomplished partly or mainly by the rising air taking its momentum with it, as Aitken suggested, it can also be seen that there is a change in the pressure field in the higher levels. Between Larkhill and Lerwick, the 400 mb isobar slopes almost twice as steeply from high to low in its new position as in its old position in Fig. 4. The air below this level in the high has become

warmer as a result of subsidence; the air below it in the low has become colder both by reason of ascent and by reason of colder air being drawn into the centre of the low. On the other hand the air above the 400 mb level has in the high become colder by ascent and in the low warmer by descent. In brief then, the density conditions for a cyclonic circulation have been partially levelled away in the lower half of the troposphere, but have been developed in accentuated form in the upper troposphere and lower stratosphere, where previously they scarcely existed. This fits in with the changes in specific momentum, as already described, between the initial and final stages of the depression.

It is to be noted that this is not how an occlusion used to be described. The simple lifting of the air in the warm sector, by cold air running under it, would not give the observed temperature distribution; and it would not give the low tropopause and the very dry stratosphere air now known to be characteristic of these low tropopauses. On the contrary it seems to be an essential part of the dynamics that there should have been a reversed vertical circulation in the upper atmosphere by means of which the depression's stratosphere was brought down and warmed adiabatically, whilst the anti-cyclone's stratosphere and upper troposphere were raised and cooled. It is to be noted that this explanation, with the difference that the demarcation between the two circulations was placed by him at the tropopause rather than, as now seems it should be, at about the 400 mb level, was put forward by W. H. Dines twenty-five years ago as a possible mechanism to account for the mean statistical relations between temperature and pressure in the upper air[3].

ENERGY DISTRIBUTION AND CHANGES

So far, momentum has been the element mostly under consideration. According to V. Bjerknes[4], if two superposed fluids of different densities with a quasi-horizontal surface of separation are in steady rotation, the surface of separation is pulled down or pushed up according as the kinetic energy of rotation is greater in the lower or the upper fluid. To examine fully whether this has an application to the tropopause of depressions we should want a sufficient number of stations to give the speeds all round the depression at a fixed distance from the centre. We could then see how the kinetic energy varied with height and with time. The observations will not as a rule allow this to be done. Values proportional to ρV^2 are, however, shown in Fig. 5 for Lerwick for the case of 9–10 March, 1943 already discussed, for times of observation 9th 20h, 10th 7h, 12h and 20h. The distance of the depression from Lerwick at the first three times was roughly 500 nautical miles; at the fourth time it was roughly 550 nautical miles, so that to make the fourth curve comparable with the others all the values of ρV^2 on it should probably be multiplied by $(550/500)^2$ i.e. by 1·21. This, however, has not been done.

The tropopause heights and types as given in the Upper Air Supplement to the Daily Weather Report are marked on the first, third and fourth curves. In the second case the tropopause was not reached. The

continuous decline in tropopause height by some 10,000 ft until it coincides with the height of maximum kinetic energy will be noted. It may be that this was accidental or that it was an advection effect, but the reader who cares to pursue the matter further by examining Fig. 5 of M.R.P. 213 (Ref. 1) may be struck by the further coincidence that substantial advection effects seem to

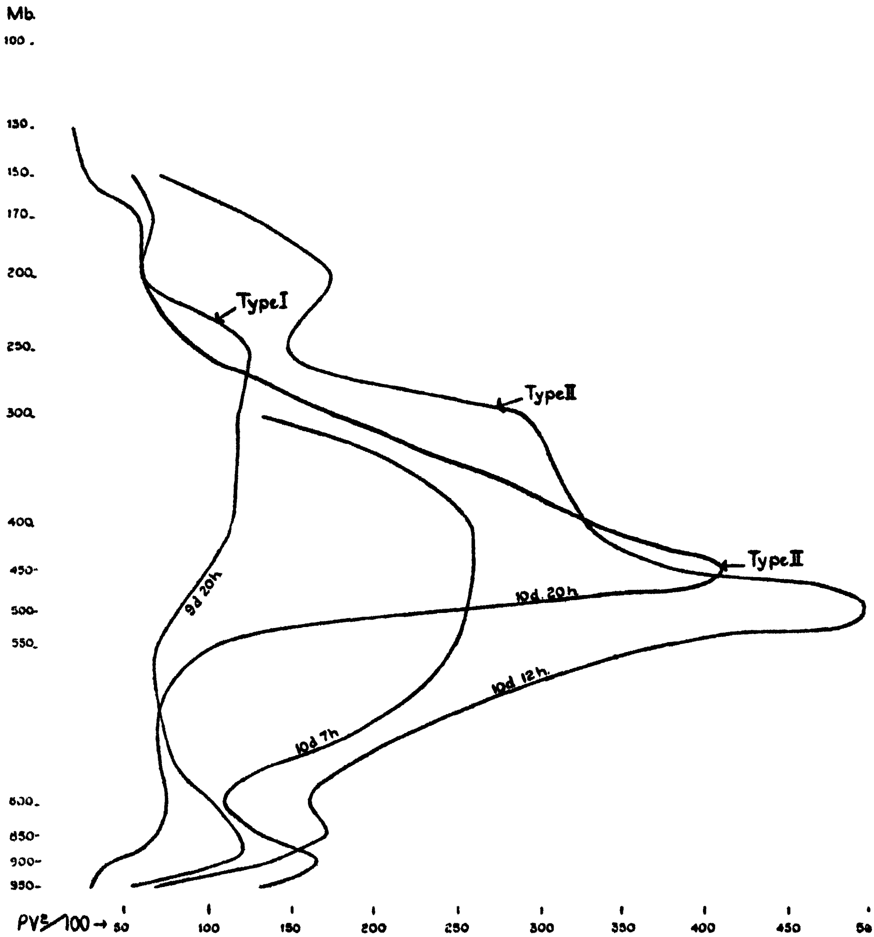


Fig. 5. Values of $\rho V^2/100$ at Lerwick, March 1943

be limited to heights within the lower of the two vertical circulations, i.e. that below the 400 mb level. Also in Figs. 6, 7, 8 of M.R.P. 213 are shown cross sections from Penzance to Lerwick of a case where, without (so far as can be determined) any advection of air of other origin, the tropopause in the centre of the picture was brought down by some 6,000 feet in 24 hours.

It may well be that low tropopauses in our latitudes have all been produced dynamically at some time or another, whether they arrive already

low or whether they are lowered within our observational area; and whether the lowering has been produced by contraction of the troposphere air (i.e. through seasonal cooling or change of latitude) or by evacuation of some of the troposphere air. The same dynamical theory offers an explanation of the process of occlusion, conceived as the drawing together of a mound of cold air in the central area of the depression to compensate for the outward evacuation of air at higher levels.

GENERAL DEDUCTIONS

(*a*) The variation of momentum with height in active depressions points to density differences in the lower half of the atmosphere in the sense required to initiate the circulations gravitationally. The conditions finally developed in the upper part of the atmosphere give the density distribution needed to account for the final momentum distribution and are in accord with W. H. Dines' statistical relations.

(*b*) In the front of depressions and probably as a rule also initially, the momentum is mainly in the lower half of the troposphere; latterly it appears to be transferred upwards and in the filling-up stage the momentum is mainly in the upper part of the troposphere.

(*c*) In the travel and formation of highs and lows two vertical circulations are involved, one below and one above about the 400 mb level. The lower is upwards in the cyclone, thence towards the anticyclone and then downwards in the anticyclone. The upper circulation involves subsidence in the stratosphere of the cyclone, and ascent in the upper troposphere and stratosphere of the anticyclone. One effect is to evacuate part of the air from the upper troposphere of the cyclone towards the upper troposphere of the anticyclone and to lower the tropopause over the cyclone.

(*d*) The difference between the cyclonic and anticyclonic stratospheres and their tropopause structures and tropopause heights would thus be explained as the dynamical effect of their local circulation, complicated usually—at least in the troposphere of the depression—by advection of the latitude differences. Type II tropopauses would usually be those which were being or had recently been lowered and the stratospheres above them would have very low relative humidity. Measurements have shown this low humidity. Type 1 tropopauses, where specially marked, would be recently formed anticyclones, and would have conditions of saturation or almost saturation below them, and perhaps even also just above them. Up to the present time, the only evidence on this point is indirect evidence from condensation trails.

(*e*) The characteristic distribution of momentum with height in anticyclones (i.e. with the maximum in middle levels, indicating a warm lower troposphere and a cold upper troposphere) is also seen to be the necessary counterpart in the high to the vertical circulations as here described.

(*f*) A point not specifically referred to as yet in this article is the horizontal movement of the air between the 200 mb and the 80 mb level. In the group of depressions dealt with in Fig. 2, the passage of the depression increased the

momentum at the 200 mb level by some 38% and at the 100 mb level by 16%. In some of the later cases dealt with individually the effects were rather more ; in others even less. Apparently the importance of the depression effects as measured by momentum thus diminish with height in the high atmosphere.

(*g*) Another point, in answer to an old question, is that the circulation at all heights above ordinary depressions, though relatively feeble at these great heights, remains cyclonic to the greatest heights reached in radio wind observations (about 18 km) and does not change into anticyclonic. Yet other evidence about which there can be no doubt shows that the larger scale planetary circulation of the summer hemisphere is an apparent exception. Below about 22 km it is on the average westerly (cyclonic) around the pole, above 22 km easterly.

Part I of this article appeared in *Weather* November 1949.

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3. W. H. Dines. *The correlation between pressure and temperature in the upper air with a suggested explanation.* Quart. J. R. Met. Soc., Vol. 51, 1925, p. 31.
4. V. Bjerknes. *On the dynamics of the circular vortex.* Geofys. Publ., Oslo 2 No. 4, 1921.

THE NEW DAILY WEATHER REPORT

On 1 January, 1950, several important changes will be introduced in the daily publications of the Meteorological Office, London. The present Daily Weather Report consists of three parts—the British, International and Upper Air Sections. These will be replaced by two publications, to be known as the Daily Weather Report and the Daily Aerological Record. The Daily Weather Report, containing surface weather maps and British observations will be published each evening as hitherto, and will carry maps and observations up to 0600 GMT on the day of issue. However, the Daily Aerological Record, containing upper air charts and observations will be published about one week in arrear in order to ensure the completeness and accuracy required by the research worker.

The main changes in contents will be the omission of observations from continental stations now contained in the International section, and the inclusion of a midday chart of the northern hemisphere in place of the present midnight map. The Daily Aerological Record will contain additional maps for 1500 GMT and the extended chart of the 500 mb level will carry thickness lines as well as contours in conformity with recent forecasting practise.

There has been an increase in subscription rates to meet increased costs, but the price of individual copies remain unaltered at 2d. (3d. post free) for each publication.

Orders should be sent to H.M.S.O., York House, Kingsway, or copies may be ordered through any bookseller.

MEETINGS AND DISCUSSIONS

GEOPHYSICAL RESEARCH

Dr. G. M. B. Dobson began his Charles Chree address to the Physical Society on 4 November by reminding his audience of Dr. Chree's work at Kew Observatory on the earth's magnetic field ; he stressed Dr. Chree's belief in the value of observations as opposed to abstract theories. He then gave a stimulating account of the joys of geophysical research, often in the open air in interesting parts of the world ; of some of the difficulties ; and of the continuing demand by theoreticians for further observations. In contrast to many branches of physics where progress was only possible by using elaborate and expensive equipment, geophysics lent itself to individual research, often with quite simple apparatus. It was soon evident to his audience, from his account of his own work, that Dr. Dobson had practised what he preached.

For the measurement of ozone in the upper atmosphere, Dr. Dobson first built a simple photographic spectrograph for a total cost of under £25, and then instigated a world-wide system of observations with similar instruments. To increase the speed and sensitivity of the measurements, he designed and made a photoelectric instrument, which has further increased scientific knowledge and whose possibilities are still being developed.

Another instrument which began in Dr. Dobson's workshop was the now famous frost-point hygrometer, with which the first measurements of the humidity in the stratosphere had been made by Mr. A. W. Brewer (see *Weather*, June 1946 p. 34). To the surprise of the theoreticians, it had been found that the air in the lower stratosphere was usually very dry ; observations were now needed at heights above the ceiling of existing aircraft.

Dr. Dobson went on to talk about recent work in the Clarendon Laboratory at Oxford on ice nuclei, a subject of great practical importance as regards the formation of rain. He concluded with a reference to some geophysical problems on which more research was required, such as radiative equilibrium at the tropopause and Sir George Simpson's remarkable measurements of the electricity of rain.

In proposing a vote of thanks to Dr. Dobson (whom he had known for 40 years $\pm$ 2 months !), Sir David Brunt pointed out the very wide field of his contributions to geophysical research, especially in the distribution of ozone, temporal, horizontal and vertical ; he considered that it would be appropriate to call the layer of maximum ozone concentration the Dobson Layer.

A. R. M., O. M. A.

CLIMATIC TRENDS

The apparent improvement in the climate in North Atlantic countries in the past 150 years was the subject of a Meteorological Office Discussion, held at Imperial College on 7 November. The opener, Mr. R. F. Zobel, reviewed an article by Professor Ahlmann in the *Geographical Journal* (1948, p. 165), in which the evidence in support of the change was presented. He considered that the combination of climatological, glaciological, oceanographical and biological information was most convincing, but until further data had been obtained from other parts of the world, especially the Antarctic, it would not be possible to say if the climatic trend was world-wide. Sir Nelson Johnson pointed out the economic importance of the changes, and remarked that a fall of only a few degrees in temperature would be sufficient to cause another ice age. Dr. C. E. P. Brooks prophesied that if the present trends continued for another 25 years, a really big change in our climate would result and we should enjoy the conditions of Saxon times.

On the cause of the fluctuations, Dr. R. C. Sutcliffe remarked that here was a happy hunting ground for theoreticians ; it was only too easy to produce a theory in a subject where insufficient data existed for proof. Cdr. C. N. Carruthers mentioned the recent increase in agriculture in Greenland, and suggested that the Hudson Bay area could be used as a barometer of climatic changes. Many other speakers contributed to the discussion but nobody ventured an opinion about what would happen in the next few years or advocated the formation of a Society for the Preservation of Glaciers !

O. M. A.

ROYAL METEOROLOGICAL SOCIETY NEWS

FORTHCOMING MEETINGS

A meeting of the Society will be held on Wednesday, 21 December, at 5 p.m., at 49 Cromwell Road, South Kensington, when the following papers will be read : "The composition of coagulation-elements in cumulonimbus," by F. H. Ludlam, and "Air motion ahead of warm fronts", by M. K. Miles. After the Annual General Meeting on 25 January, the Society will hear Sir Robert Watson-Watt's Presidential Address.

SCOTTISH SECTION

The section was fortunate in having Professor Gordon Manley to open the session on 1 November with a lecture on "The Climatic Aspects of the Glaciation of Scotland". Remarking that the almost permanent snowbeds on Ben Nevis and the Cairngorms were Scotland's nearest approach to glaciers, Prof. Manley stated that evidence from a variety of sources and comparison with Norway suggest that a "permanent snowline" would now be formed at an altitude of 5,300 ft in the Ben Nevis area. If a mountain of about that height existed in W. Scotland, small glaciers would develop on its flanks. In late Victorian times, the snowline probably lay at 5,000 ft. The appreciable rise in our mean temperature since then explains the difference.

Many mountaineers have remarked on the decrease in snow on Ben Nevis at Easter compared with 40–50 years ago. Records of early tourists such as Pennant indicate that there was even more permanent cover in the late 18th and early 19th centuries, but never enough to promote glaciers. It is likely on climatic grounds that the last small mountain glaciers in Scotland dwindled away soon after 7,000 B.C., and since then there have been long periods during which no lasting snow beds would be formed at all. It is possible that our present climatic amelioration will go further. During the Ice Age itself, summers were probably very cloudy, windy and raw ; with an enormous winter snowfall in consequence of temperatures about 17° below the present averages. Estimates can also be made of the prevailing temperatures of various stages since then, so the accumulation of facts relating to our past climate will assist in solving the problem of what the climate will do.

Messrs. Dymond, Purdon and Fotherington took part in the lively discussion that followed. It was argued whether the snowfall should be produced by lows moving as at present and whether snow would not drift off the summit because of surface drag. Thanks to the lecturer were expressed by the Chairman, Mr. J. Paton.

The next meeting on Friday, 16 December at 7.15 p.m. in the Department of Natural Philosophy, Edinburgh University, will be a general meeting to elect Office Bearers and to discuss plans for 1950. This will be followed at 7.30 p.m. by a talk on "Greenland Expedition" by Mr. F. P. Henderson of the Department of Geology.

J. P.

WEATHER OVERSEAS

We are glad to be able to announce our Representative in Malaya as Mr. I. E. M. Watts, Meteorological Office, 6th Floor, Fullerton Building, P.O. Box 715, Singapore. Mr. A. A. Black, Meteorological Office, Box 66, Causeway, Salisbury, Southern Rhodesia, will succeed Mr. J. F. Peake. Thanks to the efforts of Overseas Representatives, an increasing proportion of our space has in recent months been devoted to items from overseas, and we hope that this tendency will continue. We should be glad to hear from any readers living in countries not already included in the lists published in May, July and October, 1949, who would be willing to assist.

RESEARCHES ON UPPER WINDS

The scientific study of winds over 150 mi/hr, which constitute hazards to aviation, was the subject of a recent meeting of the Australian and New Zealand Association for the Advancement of Science, held in Hobart. It was pointed out that during World War II strong winds of up to 270 mi/hr, experienced over Tokyo, almost threatened the success of the precision bombing of the Japanese capital: superfortresses on the way to the target sometimes remained motionless for half an hour. Very strong winds occurred mainly in the upper air in the 20,000 to 40,000 ft layer; available publications showed extreme values of 270 mi/hr over Japan and 230 mi/hr at Blue Hill, U.S.A.

When plotted against latitude, the strongest winds suggested a curve in which the extremes were about 170 mi/hr at latitude 60°, rising to 270 mi/hr at 35° and falling gradually to 150 mi/hr at 15°. This distribution arose from the dependence of strong winds on the maximum pressure gradients, which probably did not vary much from latitude 60° to 40°, but decreased steadily from there to lower latitudes. Owing to the earth's rotation, the wind was much stronger for the same pressure gradient in a lower than in a higher latitude.

Dr. H. M. Treloar stated that extreme increases of wind with height had been studied in connection with the inauguration of the Tasman air service, and that increases of 100 mi/hr between 3,000 and 16,000 ft had been found. It seemed that the extreme values of the vertical increase of wind never exceeded the theoretical limit given by the Richardson criterion, but much further study was needed upon the interpretation of this theoretical aspect.

DUST-DEVILS IN THE SUB-ARCTIC

Dust-devils are generally reported from tropical zones, but they have been observed in the western Canadian Arctic at a latitude of 65°N. At approximately 1400 GMT on 11 June 1949, a large migratory dust-devil was seen at Goose Airport, Labrador (latitude 53° N) by Mr. A. St. C. G. Grant, a Canadian meteorologist. Surface observations taken at a point two miles WNW of the location of the devil at 1320 GMT were :— Overcast, Sc at 5,000 ft, Visibility 30 miles, Temperature 59°F, Dewpoint 44°F, Wind west 15 mi/hr. By 1420 the cloud had decreased to four-tenths, the temperature

increased to 62°F, and the dewpoint decreased to 42°F. Goose Bay upper-air observations at 1500 GMT showed a superadiabatic lapse rate from the surface to 4,600 ft and a 10-knot wind from 250° in the lower 4,000 ft of the atmosphere. The 1230 GMT synoptic chart indicated an almost stationary cold front 25 miles north of the station ; the air mass over the region was polar continental, modified considerably after a 4 to 5-day trajectory from western high latitudes.

The dust-devil was first noticed about 75 ft from the observer, drifting ENE at about 10 mi/hr. Its diameter was estimated to be about 20 ft, the height at least 150 ft, developing to a maximum of 200 to 300 ft. Its axis was nearly vertical. The highest winds in the whirl, which was turning anti-clockwise as viewed from above, were estimated at 40 to 50 mi/hr. Sand, debris, small branches and twigs were carried upwards, several pieces of card-board about 1½ ft square to a height of 150 ft. Two other dust-devils, 6 and 25 ft high, were seen nearby later in the day.

HAIL IN THE BATHROOM

Mr. C. E. Thompson reports that Edmonton, Alberta, had its most severe hail- and rain-storm in history on 16 July 1949, when 2·56 in. of rain accompanied a damaging hail-storm. In the basement of the Royal Canadian Mounted Police barracks, the drainage water, backing up, brought hailstones up through the plumbing, overflowing shovelfuls on to the floor. The deluge ended a spring and summer drought that had ruined crops and brought disastrous forest fires to the area.

DUBLIN METEOROLOGICAL AND GEOPHYSICAL SEMINAR

At a meeting on 3 November 1949, Dr. T. E. Nevin reported on the present state of our knowledge of the light of the night sky, both practical and theoretical. He stated that on a moonless night the total light was much more than that coming from the stars, and most of it originated in the upper atmosphere. Analysis revealed that many different wavelengths were present, some undoubtedly due to the presence of oxygen, some to nitrogen and others to minute traces of sodium. A few lines in the spectrum were still not adequately explained. Dr. Nevin discussed the difficulties to be dealt with, and touched on the relations with aurorae and with changes in the earth's magnetic field.

The next meeting will be on 5 January 1950, in the School of Cosmic Physics, 5 Merrion Square, Dublin, when Mr. P. M. A. Bourke will talk on " Practical meteorology in the service of aeronautics ".

ABNORMAL SWISS WEATHER

October 1949 was one of the warmest months since the beginning of regular observations in Switzerland (1864), with a mean temperature at Zurich of 52·2°F, 6·3°F above the 80-year mean. The duration of bright sunshine

exceeded the mean by 50 per cent, a value only exceeded in October 1921 and 1931. Total rainfall was only 25 per cent of average; with the exceptions of January and April 1949 rainfall has been below normal for 14 consecutive months.

RAIN OF MUD AT KIMBERLEY

A mudstorm was experienced at Kimberley on 7 September 1949. The local meteorologist, Mr. Groves, reported that dark reddish patches were observed in Cu and Sc clouds at 1000 hr and were later identified as clouds of dust. By 1330 it was difficult to see indoors without the aid of lights, and the falling rain was thickened to a mud. Samples of paper exposed to the "mud" rain by Mr. Groves confirmed reports in the local press that "As the mudstorm eased off, Kimberley became a brown city, with cars, buildings, the leaves of trees, and even people coated with mud". A sample of the rain was analysed and found to contain 0·81 per cent (about $1\frac{1}{4}$ oz per gallon) of fine silt, all of which passed through a sieve having a mesh of 0·2 mm. (This and the two following paragraphs are from the monthly news letters of the South African Weather Bureau).

CALIBRATION OF RADIOSONDE ELEMENTS

A refrigerated pressure chamber for the simulation of upper air conditions for the calibration of radiosondes (Canadian type) has been set up in Pretoria The specifications provide for a pressure reduction to less than 30 millibars and for the electronic stabilization of temperature at preset values down to −70° C (−95° F); in an initial test the temperature was lowered to −60° C in half an hour, and the pressure to 30 millibars in 15 minutes. It will be possible to accommodate 40 or more radiosonde instruments in the chamber simultaneously and to carry out the calibration in batches of eight at a time. An eight-pen chronograph for reading radiosonde signals for calibration purposes arrived from Canada in June, and the routine calibration of radiosondes will begin as soon as the equipment for mounting the instruments during calibration has been completed.

WEATHER BULLETINS FOR SHIPPING

On 7 June a new form of Weather Bulletin for shipping was introduced to conform to I.M.O. recommendations made at the Washington Conference of Directors. The new bulletin consists of three parts: (*a*) storm warnings, (*b*) synopsis of weather conditions in the forecast area, and (*c*) forecasts. The forecasts cover the coastal waters and 50 miles seaward from Walvis Bay to Lourenço Marques; and in addition the following portions of main shipping routes—Cape Town to the vicinities of St. Helena and Tristan da Cunha—Durban and Cape Town to 50° E on the Australian routes. The complete bulletins, which are prepared for the Weather Bureau by the Fleet Meteorological Officer at Simonstown, are broadcast twice daily from Cape Town, appropriate portions being transmitted also from the radio stations at Walvis Bay, Algoa Bay and Durban.

THE DISASTROUS WEATHER OF 1684

By D. E. Bowen, F.R. Met. S.

The last two winters having been exceptionally mild, it is interesting to review in some detail the main events of harsh winters that occurred many years ago. To the readers of John Evelyn's Diary there can be no doubt that the winter season of 1683-1684 was one of the severest on record. It was comparatively mild until mid-December but this situation was completely reversed about Christmastide when there followed a bitter January and an upset of the seasons for the rest of the year.

Evelyn makes it quite clear that the unusual conditions of January 1684 were by no means confined to the area of his native London or, for that matter, to the British Isles. But the Londoners of that year were able to witness one of the most spectacular of Thames frost fairs. The following account is not only informative from the meteorological and climatological points of view; it is a brilliantly told episode in the social history of England:

1684: January 1: The weather continuing intolerably severe, streets of booths were set upon the Thames; the air was so very cold and thick, as of many years there had not been the like....
January 6: The river quite frozen.
January 9: I went across the Thames on the ice, now become so thick as to bear not only streets of booths, in which they roasted meat, and had divers shops of wares, quite across as in a town, but coaches, carts, and horses passed over. So I went from Westminster-stairs to Lambeth, and dined with the Archbishop.... After dinner and discourse with his Grace till evening prayers, Sir George Wheeler and I walked over the ice from Lambeth-stairs to the Horse-ferry.
January 16: The Thames was filled with people and tents, selling all sorts of wares as in the City.
January 24: The frost continuing more and more severe, the Thames before London was still planted with booths in formal streets, all sorts of trades and shops furnished, and full of commodities, even to a printing-press, where the people and ladies took a fancy to have their names printed, and the day and year set down when printed on the Thames: this humour took so universally, that it was estimated the printer gained £5 a day, for printing a line only, at sixpence a name, besides what he got by ballads, etc. Coaches plied from Westminster to the Temple, and from several other stairs to and fro, as in the streets, sleds, sliding with skates, a bull-baiting, horse and coach-races, puppet-plays and interludes, cooks, tippling, and other lewd places, so that it seemed to be a bacchanalian triumph, or carnival on the water, whilst it was a severe judgment on the land, the trees not only splitting as if lightning-struck, but men and cattle perishing in divers places, and the very seas so locked up with ice, that no vessels could stir out or come in. The fowls, fish, and birds, and all our exotic plants and greens, universally perishing. Many parks of deer were destroyed, and all sorts of fuel so dear, that there were great contributions to preserve the poor alive. Nor was this severe weather much less intense in most parts of Europe, even as far as Spain and the most southern tracts. London, by reason of the excessive coldness of the air hindering the ascent of the smoke, was filled with the fuliginous steam of the sea-coal, that hardly could one see across the streets; and this filling the lungs with its gross particles, exceedingly obstructed the breast, so as one could scarcely breathe. Here was no water to be had from the pipes and engines, nor could the brewers and divers other tradesmen work, and every moment was full of disastrous accidents.

February 4 : I went to Sayes Court to see how the frost had dealt with my garden, where I found many of the greens and rare plants utterly destroyed. The oranges and myrtles very sick, the rosemary and laurels dead to all appearance, but the cypress likely to endure it.

February 5 : It began to thaw, but froze again. My coach crossed from Lambeth to the Horse-ferry at Milbank, Westminster. The booths were almost all taken down, but there was first a map or landscape cut in copper representing all the manner of the camp, and the several actions, sports,and pastimes thereon in memory of so signal a frost.

Now to Evelyn's colleague, Samuel Pepys, and to the people of Restoration England a *warm* winter was a sign of a "sick summer" to follow. Whether or not the bitter winter of 1684 gave some solace in that they could prognosticate a fruitful and prosperous year to follow is not known, but it *is* known that the spring and summer of that year were as formidable and calamitous as the preceding winter :

April 4 : . . . hardly the least appearance of any spring.

July 2 : . . . There had been an excessive hot and dry spring, and such a drought still continued as never was in my memory.

July 13 : Some small sprinkling of rain ; the leaves dropping from the trees as in autumn.

August 10 : We had now rain after such a drought as no man in England had known.

August 24 : Excessive hot. We had not had above one or two considerable showers, and those storms, these eight or nine months. Many trees died for the want of refreshment.

This last statement serves as a good criterion for judging the minute amount of the spring and summer rainfall, and from the continuation of Evelyn's account it would seem as though 1684 produced some good harvesting months with precious little to harvest. And then there was yet another severe winter for which the nation was ill prepared :

November 2 : A sudden change from temperate warm weather to an excessive cold rain, frost, snow, and storm, such as had seldom been known. This winter weather began as early and fierce as the past did late . . . .

1685 : January 1: It proved so sharp weather, and so long and cruel a frost, that the Thames was frozen across, but the frost was often dissolved, and then froze again.

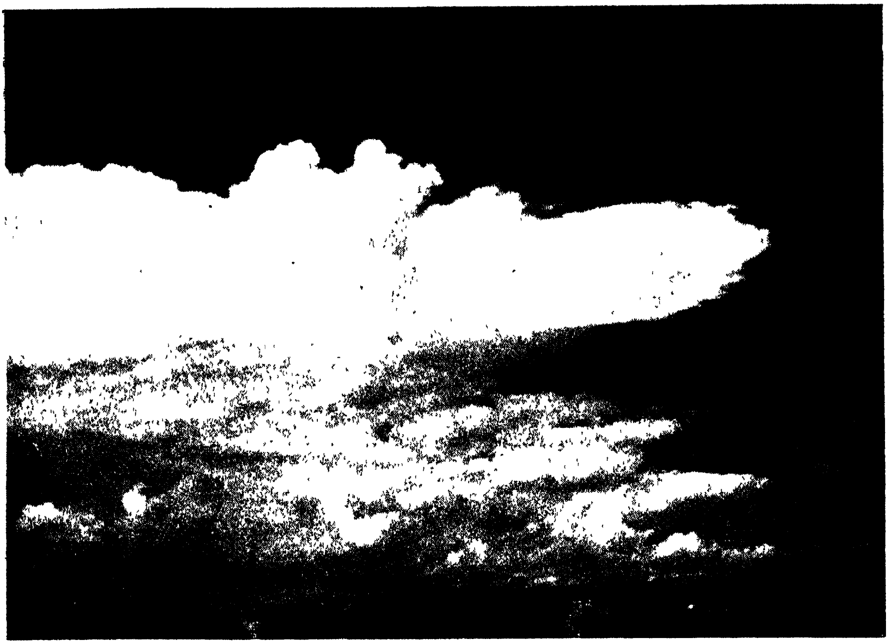
There can be little doubt that so barren a year as 1684 was generally regarded as a sign of God's displeasure, for even at the beginning of this reign of Charles II, on the occasion of the storm of 1662, Evelyn had remarked :—". . . so exceeding was God's hand against this ungrateful and vicious nation and Court." At such a time there must have been many who could recite extempore the famous words contained in the *Book of Common Prayer* :

. . . Send us, we beseech Thee, in this our necessity, such moderate rain and showers, that we may receive the fruits of the earth to our comfort, and to Thy honour . . . ."

Erratum

Weather, Vol. 4, No. 10, October 1949 p. 331 : please substitute the following equation for that given in the second paragraph of the letter entitled " Wet Januaries and Septembers " ;

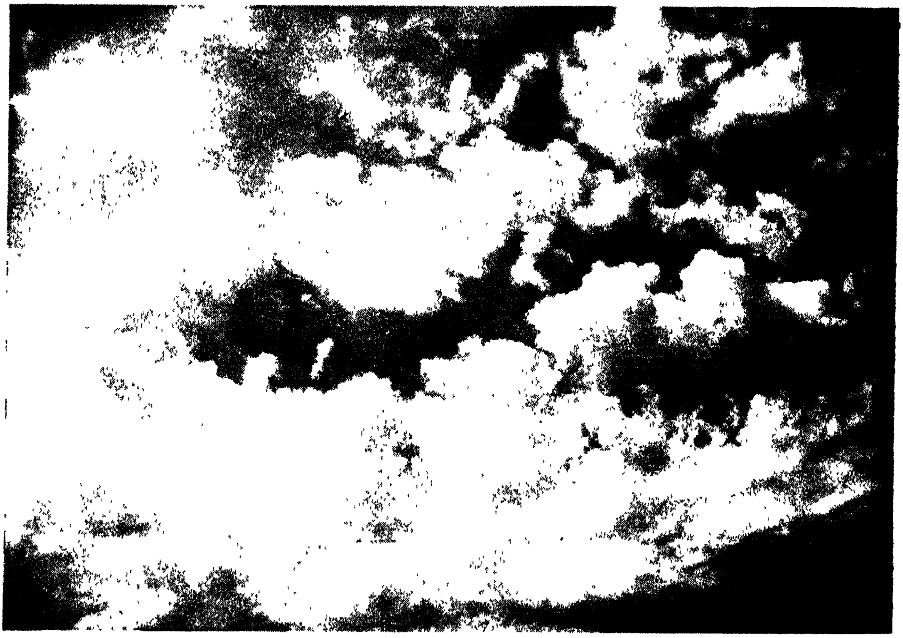
$$P = \frac{1}{{}^{n}C_{l}} \left[\sum_{j=1}^{k} (-1)^{j+1} \quad {}^{m+1}C_{j} \quad {}^{l-js}C_{m} \right]$$

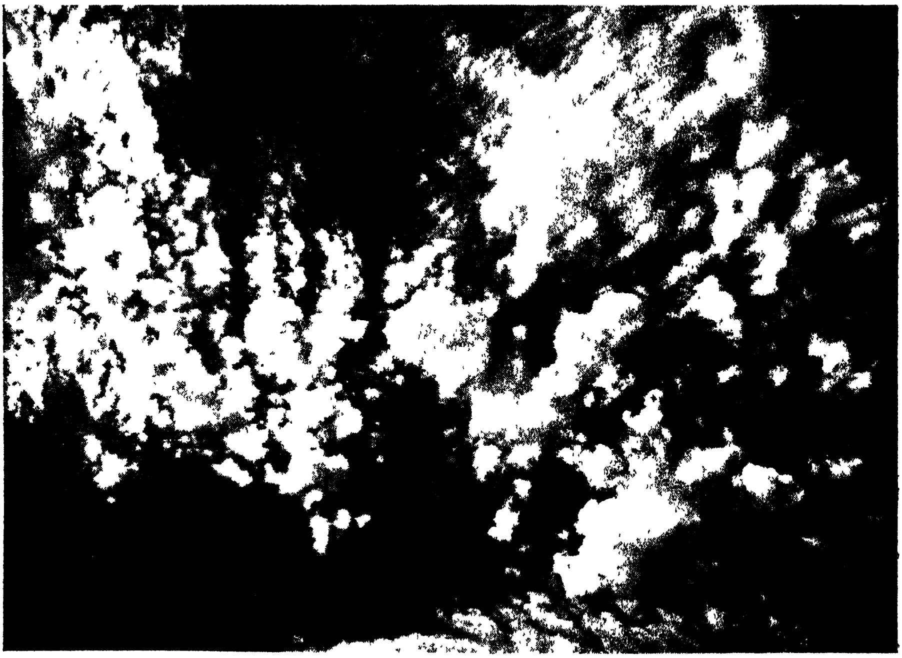


Thunderstorm Clouds from a distance

Photographs by] [*the late G. A. Clarke*

PLATE III





Examples of Alto-cumulus castellatus -- a rare summer cloud

Photographs by] [*the late G. A. Clarke*

PLATE IV

THE WEATHER OF NOVEMBER 1949

UNSETTLED

November's weather, unlike many recent months, was uneventful and ran more or less according to form: the average temperature and rainfall were generally about normal, and sunshine totals, though rather generous over much of England, were elsewhere close to the average; mean pressure was, however, well below the average everywhere.

The month opened with an anticyclone over Central Europe and a ridge covering Southern England; screen minima below 30°F were reported from many places in the South and East (25°F at Mildenhall and London Airport on 1st and 2nd respectively). From 3rd to 13th the weather was of an unsettled westerly type accompanied from time to time by rain and strong winds reaching gale force locally in the West and North. On 14th a ridge moved in from the Atlantic and there were three days of quiet weather, though foggy in the London area, with some low screen minima, notably 24°F at Cranfield on 15th. After some frontal rain on 17th and 18th (44 mm in 12 hr at Exeter) there were two more days with widespread fog other than in the west.

On 21st a deep depression west of Scotland caused gales in all areas, and on 23rd a secondary moving south-eastward over the mouth of the English Channel caused severe gales to the southward of its path. This depression became nearly stationery over NE. France and was associated with a spell of north-easterly winds over Britain; temperatures were, however, above average for the time of year because the air was of southerly origin, skies were mostly overcast, and the temperature of the North Sea had not yet fallen much below 50° F. After the quick passage of a ridge southwards on 28th to 29th, unsettled westerly type weather again became established on 30th.

The Philippines experienced what is described as the worst typhoon for many years on 31 October, and 200 people lost their lives on Negros Island. A week of heavy rain caused a great deal of damage and much distress in Northern Italy, 2,000 persons were rendered homeless in the low quarters of Cherbourg, and hailstones larger than tennis balls wrought damage estimated at £250,000 at Pretoria. Had it not been for an aerial survey sponsored by the Royal Geographical Society of South Australia, 1,000 square miles of water in the normally dry Lake Eyre would have passed unnoticed; this was, apparently, a beneficial result of the heavy winter rains in Western Queensland.

	TEMPERATURE (°F)				RAIN (mm)*			SUNSHINE (hr)		
	Long period Average		This month Extreme		Month	Diff. from Av.	Last 12 months	Month	Diff. from Av.	Last 12 months
	Max.	Min.	Max.	Min.						
Kew Obsy.	48·6	40·0	57	27	55	— 2	498	65	+12	1783
Gorleston	48·6	40·8	56	30	66	+ 5	412	68	+ 2	1788
Birmingham	46·9	39·0	53	32	83	+22	717	57	+11	1573
Falmouth	51·6	43·9	†56	†36	149	+27	949	93	+17	2022
Valentia	51·2	43·7	57	36	212	+76	1466	64	+ 1	1419
Aldergrove	47·9	39·1	54	28	61	—22	737	60	+ 2	1356
Holyhead	49·7	44·4	57	35	90	—15	768	55	— 9	1821
Tynemouth	47·5	40·4	55	32	75	+21	415			
Renfrew	46·1	36·1	55	29	113	+14	1109	44	0	1438
Aberdeen	45·5	36·2	53	26	117	+33	764	52	—15	1549
Stornoway	47·2	39·6	54	30	147	+ 4	1181	47	+ 1	1285

* 25 mm = 1 inch (approx.)　　† The Lizard　　C.R.B.

Books Received

Climatology, by W. G. Kendrew ; 383 pages, 125 figures, 16 plates. Oxford University Press, 1949, 30s.

This book is really a third edition of *Climate*, altered so much in the process of bringing it up to date as to merit a new title. The full title, *Climatology—Treated Mainly in Relation to Distribution in Time and Space*, must not be taken to imply any serious overlap with Brook's *Climate Through the Ages*, recently reviewed in *Weather* ; the time scales dealt with by the authors are so vastly different that the books are essentially complementary. Large sections of the book have been entirely rewritten and the more comprehensive treatment given to radiation, wind and ocean currents (a diagram showing the main currents would be a further improvement) more than compensate for an occasional repetition and a few slips. It must be very difficult for authors to keep abreast of scientific advances nowadays ; in future editions Mr. Kendrew will have to revise the section on absorption of infra-red radiation by the atmosphere and his statement that in the Antarctic " no ground is bare of snow ".

Climatology does not lend itself readily to a systematic treatment, and although Mr. Kendrew has succeeded in presenting an authoritative survey, which is considerably better than the earlier editions, the book still lacks that elusive something which makes the difference between a book that after a first reading is only used for reference and one that is frequently dipped into for pleasure. Nevertheless, *Climatology* should be bought by every student of the subject and by anybody who wants to find out what it is all about.

O. M. A.

Ultra-violet and Daylight Rays in the Solar Cycle, by J. R. Ashworth, D.Sc. ; 73 pages, 11 figures, 11 tables. University Press of Liverpool, 1949.

We are singularly ill-equipped with simple instruments for recording daily totals of daylight. As a recorder of hours of sunshine the Campbell-Stolies, with its glass sphere, is effective and easy to read, but it does not measure total daylight. Dr. Ashworth's Meter does so with home-made photographic paper and, on this side of the Atlantic at any rate, it seems to be the only instrument of its kind that has stood the test of time.

Dr. Ashworth claims that it has revealed enormous variations in the quality of solar radiation. At sun-spot maximum ultra-violet is strong relative to visible ; at the minimum only half as strong. His argument is subtly presented, but how are we to believe that solar-physics observations, using far more sensitive instruments, have missed such an important matter ?

A. R. M.

CHRISTMAS CARDS

The Society has arranged to print Christmas Cards for the convenience of Fellows, which are available at 4s. for six (minimum order) or 7s. 6d. per dozen. The cards are similar to those printed last year except that the wording is in brown and photograph is " Wind effects on snow in a railway cutting near Barras, Westmoreland on 19ᵗʰ February 1947 " (by courtesy of British Railways).

Orders should be sent now to the Assistant Secretary at the Society's office enclosing a cheque or crossed postal order for the appropriate amount. Envelopes should be marked " Christmas Cards."

ORDER FORM

To Royal Meteorological Society (*Weather*),
49, Cromwell Road,
London, S.W.7.

I wish to receive *Weather* for twelve months, commencing..........................
for which I enclose a remittance of 18*s*. 0*d*. (cheque of crossed postal order).

Name (BLOCK LETTERS) ....

Address (BLOCK LETTERS)......... ....

Date..

LETTERS TO THE EDITORS

Meteorology in the Universities

Mr. S. E. Ashmore in his interesting account of the teaching of meteorology in Grammar Schools expresses the conviction " that the study of it [meteorology] in Colleges should be, as at present, post-graduate ". This is a view that appears to be widely held in this country and in my opinion its effects are unfortunate.

In most British Universities, the honours graduate in Physics has proceeded to his degree without encountering any of the applications of physics to meteorological problems. How can we expect to attract graduates to meteorology if they are not given an opportunity of making even a slight acquaintance with the subject during their undergraduate course ? A short course during the honours year on the applications of thermodynamics and hydrodynamics in fundamental meteorological theory (and including, if possible, a summary of recent work on the upper atmosphere) would serve not only to bring the problems of meteorology before the potential specialist, but also to give deeper insight into these two physical subjects. Curricula in Honours Physics have become very heavy, but surely at least a few of the larger Universities are sufficiently staffed to provide a short course of this kind. Preferably, it should be an optional course, which, by supplying one or two extra questions in final examination papers, would offer an increased selection to those candidates who attend it.

But there is also scope for a general course open to students for an ordinary degree who hold Higher School Certificates in physics and mathematics. Such a course might begin with an account of the history of the development of meteorology and proceed to a short study of those branches of physics (e.g. Elementary Thermodynamics, the Theory of Heat Radiation and the Physics of Water-vapour) that must be thoroughly understood before embarking on meteorological theory. The following sequence may then be followed. The heat exchanges of the earth and atmosphere ; the world distribution of temperature ; the vertical distribution of temperature ; thermodynamic diagrams ; the dynamics of air movement ; geostrophic and gradient wind equations ; the general circulation of the atmosphere ; the variation of wind with height in the free atmosphere ; the physical processes of cloud and fog formation and of precipitation ; synoptic meteorology ; the upper atmosphere and the elements of climatology. If the course extends over a complete session (say 75 lectures) it may also include a study of atmospheric optical phenomena and the elements of atmospheric electricity and terrestrial magnetism. A dip into the *Workbook in Meteorology* by Spilhaus and Miller (McGraw Hill, 1942) will reveal what may be tackled in tutorials and practical work. A conveniently situated observation point (e.g. a flat roof) with a clear view of the whole sky is, of course, a very essential part of the meteorological laboratory ! The scope of such a course is undeniably wide and the treatment must inevitably be fairly elementary, but the standard need not be below that of a first year university course in a subject which is not previously studied systematically at school. Many of the students who would elect to take this course would become science teachers. If they have become interested in the subject—and being a subject of which the manifestations are continuously visible and often tangible, it is likely to interest most of its students—they are bound to infuse into their teaching of physics the many excellent illustrative examples in which meteorology abounds.

Undergraduate courses of this kind, both general and advanced, have been given in Edinburgh since 1945.

Edinburgh — JAMES PATON

Reflection

It is a well-known fact that even on days of sunshine the presence of snow results in lower air temperatures than if the ground were bare, for the snow surface can never rise above a temperature of 32 degrees Fahrenheit, which means that the snow cannot warm the air to any extent. Yet, after an experience of a typical winter's afternoon spent on the Eildon Hills in the county of Roxburghshire, the writer feels that an exception must now be made to the general order of things, like the irregular verb to one who attempts to master French.

It was there he discovered that on a windless day the air can be remarkably hot above a snow cover, especially if this is of concave formation, and acts as a kind of magnifying mirror that gathers the sun's rays in its optical focus. It was decided to make an investigation on practical lines to inquire whether the sensory experience that had been enjoyed was illusory. The apparatus consisted of eight mercury thermometers which could be relied upon to give reasonable accuracy, despite the fact that they did not possess N.P.L. certificates. The screens for the thermometers were of home-made construction, made to approximate to Stevenson screen standard. They were raised to six feet above

ground, instead of the usual four feet, since the former was the height of the observer, who had experienced the heat at that height above the snow surface.

The whole purpose of the experiment was to show that a concave snow surface on a hillside exposed to direct sunlight in mid-winter, could give an abnormally high temperature reading. It was felt that this could be considered proved if practically simultaneous readings were taken of four thermometers, suitably screened, on a flat snow surface exposed to direct sunlight at the foot of the hill, contrasted with the same " set up " further up the hill. Two of the thermometers indicated the temperature of the snow surface, and the other two, the temperature of the surrounding air six feet above the snow surface.

The results obtained were as follows :—

Weather—Fine, Wind—Calm, Visibility—Excellent.

General level of land at foot of hills 375 feet (approx.) above Mean Sea Level.

	A	B	C
Temperature of snow surface	20°F	19°F	17°F
Temperature at 6 feet	28°F	62°F	25°F
Temperature difference	8°F	43°F	8°F

NOTES : A. Snow patch at foot of hill ; B. Snow patch 300 feet up ; C. Snow patch 300 feet up when, a few hours later, sun was entirely obscured by cloud.

From the tables, it can be seen that the experience of abnormal warmth had not been a figment of the imagination, but that the most unnatural warmth enjoyed had actually occurred. One concave snow patch had produced an " irregular verb " !

Melrose, Scotland G. BAIN ROSS

"Snowball" as a Nickname

During a brief visit to Devonshire not long ago I heard, whilst watching a group of country lads at play, one of them being dubbed " Snowball," and I recollected having also heard this nickname given among boy scouts in a London suburb. The dual incident from widely separated parts of Southern England and from both a rural and an urban environment interested me as reflecting a general influence in our climate, and it made me wonder whether the frequency of such a sobriquet as a natural linguistic growth would bear any relation to the snowiness of different parts of the country. Naturally, in any investigation, allowance would need to be made for such factors as local density of population and the degree of isolation of different communities.

The incident further interested me in connection with the much wider subject of the snow-lore of Great Britain which is quite remarkably rich. I have watched local literature and conversation all my life in this light, and have gained the strong impression that there is no corner of Britain whose country folk-lore is not in some measure stamped with the imagery of snow and which does not enshrine tales to the setting of a severe snowstorm.

Hampstead, London L. C. W. BONACINA

English Weather Types

There are several points in the article " Fifty Years of English Weather " in *Weather* of July 1949 which raise some doubts as to the efficacy of such a classification.

First, as regards the definition of " anticyclonic type," this should surely be amended to read " centred over England ". If centred " near Britain ", surely some sort of air flow would be set up and the chart would have to be assigned to one of the other types. Second, why should the northerly type be designated " cyclonic " ? If the criterion is curvature of the isobars, why should the division not be made for all other types and what becomes of the fair northerly type which can occur for days with a strong high to west of Ireland.

Another difficulty inherent in such a classification is the persistent refusal of the weather to conform to type. In the portion of the article headed " Conclusions ", it is implied that all southerly types in January are mild. This is not always so. If a polar flow travels round a slow-moving low to West of Ireland the air is cold although the wind is southerly. It is not true to say that, owing to the increase in the incidence of westerly types in July, there is less chance of thunder. Thunderstorms seem on the average to occur more frequently with fronts travelling in westerly currents in July than they do, say, in April.

There are several other seeming contradictions in the same portion of the article, and on the whole it would seem to be questionable whether the practical results of a classification of this kind warrant the labour so obviously expended upon them.

Romiley, Cheshire FRANK EDWARDS

Black Bulb in Vacuo

Maybe some will regard as a hideous anachronism the appearance of a letter in 1949 on this subject, particularly as Sir Napier Shaw's attacks upon the instrument were being carried on more than forty years ago, as I found out when referring to the *Meteorological Magazine* for 1908. However, I make the admission that there is a black bulb in vacuo in Wrexham, properly exposed, which is read and set as faithfully as all the other thermometers. We cannot run to the apparatus necessary for determining the number of calories per sq cm per min received from the sun at Wrexham, so this old instrument goes on informing us whether today's intensity is greater than yesterday's, even if its limitations do not permit it to do more than that.

I thought that Mr. L. C. W. Bonacina, who defended the instrument in 1908 and wrote to *Weather*, August 1949, about the sun-power of the previous June, might like to know that his impressions were amply supported by the solar maximum thermometer here, particularly at the end of the month. On June 27 the figure of 145·8° F was the highest ever registered here. The high readings of July were equally noteworthy. They are much lower than those obtained in the South of England, most of the difference being due, apparently, to the custom there of exposing the thermometers on the grass and not at 4 feet.

Wrexham — S. E. Ashmore

Mother-of-Pearl Clouds

In the June 1947 number of *Weather* (p. 187), and in a subsequent number, January 1948 (pp. 2–9 and pp. 13–18), there appeared a very interesting series of articles on the above phenomena. It was pointed out that on the rare occasions in which mother-of-pearl clouds had been seen, they were first observed from Norway and later from Scotland. No mention is made of their ever having been seen from any other country.

The writer was much interested, therefore, to receive a private communication to the effect that they had been seen from the Nilgiris Hills, India, in lat. 11° N, about 6,000 ft up. They were first observed "about April 1923" and then "recurred two days later. No one at the time could explain the sight, or had seen it before."

A description of the clouds as witnessed by the observer and his colleagues in India, puts the matter beyond all reasonable doubt, that they were none other than the mysterious mother-of-pearls.

Professor Carl Störmer has said that these clouds "were seen almost exclusively in the winter months of December, January and February". It is interesting to note, therefore, that they were reported as observed from India in the month of April.

Melrose, Scotland — G. Bain Ross

Ye Clerke of ye Wethere

A Clerke there was, a puissant wight was hee,
Who of ye we there hadde ye maisterie;
Alway it was his mirthe and his solace—
To put eche seson's wethere oute of place.

Whanne that Aprille show ers wer our desyre,
He gad us Julye sonnes as hotte as fyre;
But sith ye summere togges we donned agayne,
Eftsoons ye wethere changed to cold and rayne.

Wo was that pilgrimme who fared forth a-foote,
Without ane gynham that him list uppe-putte;
And gif no mackyntosches eke had hee,
A parlous state that wight befelle—"pardie".

We wist not gif it nexte ben colde or hotte,
Cogswounds! ye barde a grewsome colde hath gotte!
Certes, that clerke's ane mightie man withalle,
Let non don him offence, lest ille befalle.

Hastings — I. M. Peatfield

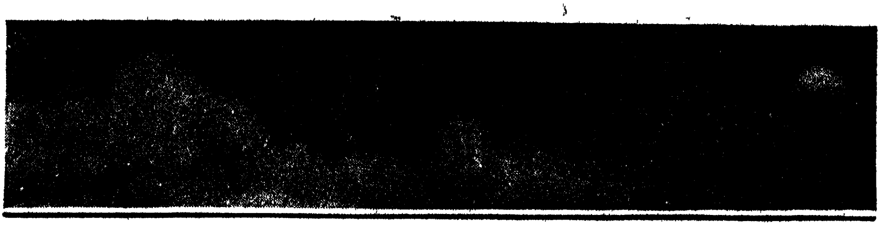
STATES OF JERSEY AIRPORT.
METEOROLOGICAL VACANCIES.

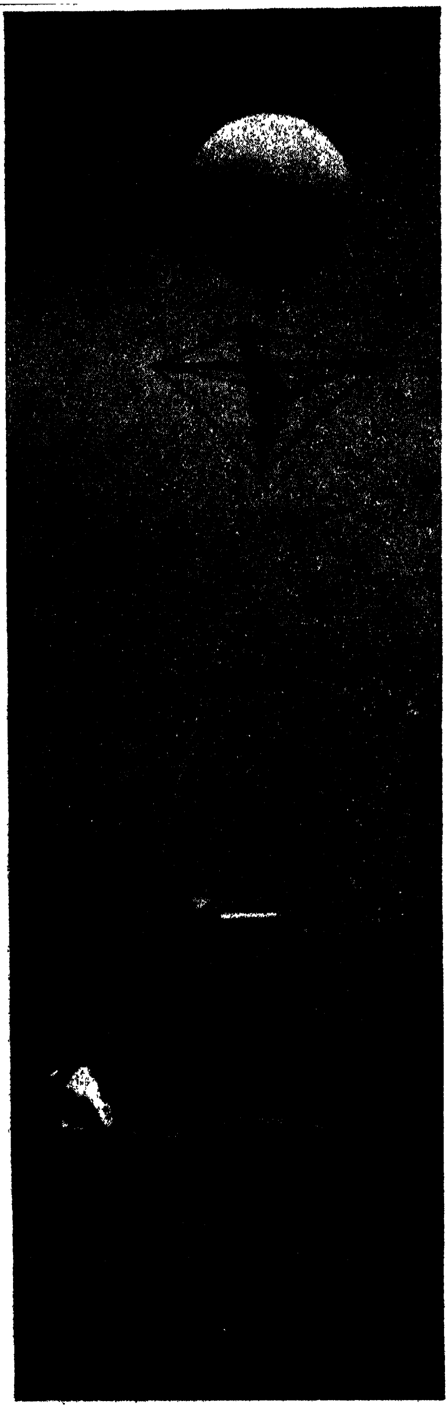
Applications are invited to fill vacancios for Meteorological Assistants at Jersey Airport. Candidates should have had some years experience in an aviation Meteorological Office and have reached matriculation standard in Physics and Mathematics. The salary offered is £270–£330 according to experience, qualifications, etc. Owing to the housing shortage in the island it is regretted that preference must be given to unmarried applicants. Write, giving full particulars, to the Airport Commandant, States of Jersey Airport, Jersey, C.I. Further details will then be forwarded to suitable applicants.

VACANCIES

Messrs. Imcos Ltd., have vacancies for trainees (female) for posts of Assistant Forecaster/Climatologists. Duties include short and long-range forecasting (KRICK method); study of long-range forecasting techniques; climatological survey work, statistical analysis, etc. Some meteorological training essential; knowledge of air-mass analysis desirable; shorthand and typing useful. Salary according to qualifications. International Meteorological Consultant Services Ltd., 200, High Holborn, W.C.1.


A "Record" worth having
This Radiosonde was developed by Salford Electrical Instruments Ltd., in conjunction with the Met. Office, and is being manufactured in large quantities. It comprises a radio transmitter which is modulated alternatively by an audio-frequency which depends upon the temperature pressure and humidity. The met. elements have been chosen for their stability and cyclicity, and its results are better than any similarly priced instrument in the world
Where it is necessary to use a really accurate and reliable Radiosonde, capable of simple interpretation of results, the "Salford" Radiosonde cannot be improved upon The instruments we offer are individually calibrated, ensuring that the potential accuracy is always attainable.
Production is on a large scale, and this Company is always in a position to give a quick delivery for export, in addition to those which are being supplied in large quantities to the Meteorological Office. We shall be pleased to supply full technical data on request.
Salford Electrical Instruments Ltd.
PEEL WORKS SILK STREET SALFORD





RELEASE OF RADAR REFLECTOR MARK IIB FROM UNITED STATES NAVAL RESEARCH LABORATORIES

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